



**US Army Corps  
of Engineers®**  
Engineer Research and  
Development Center

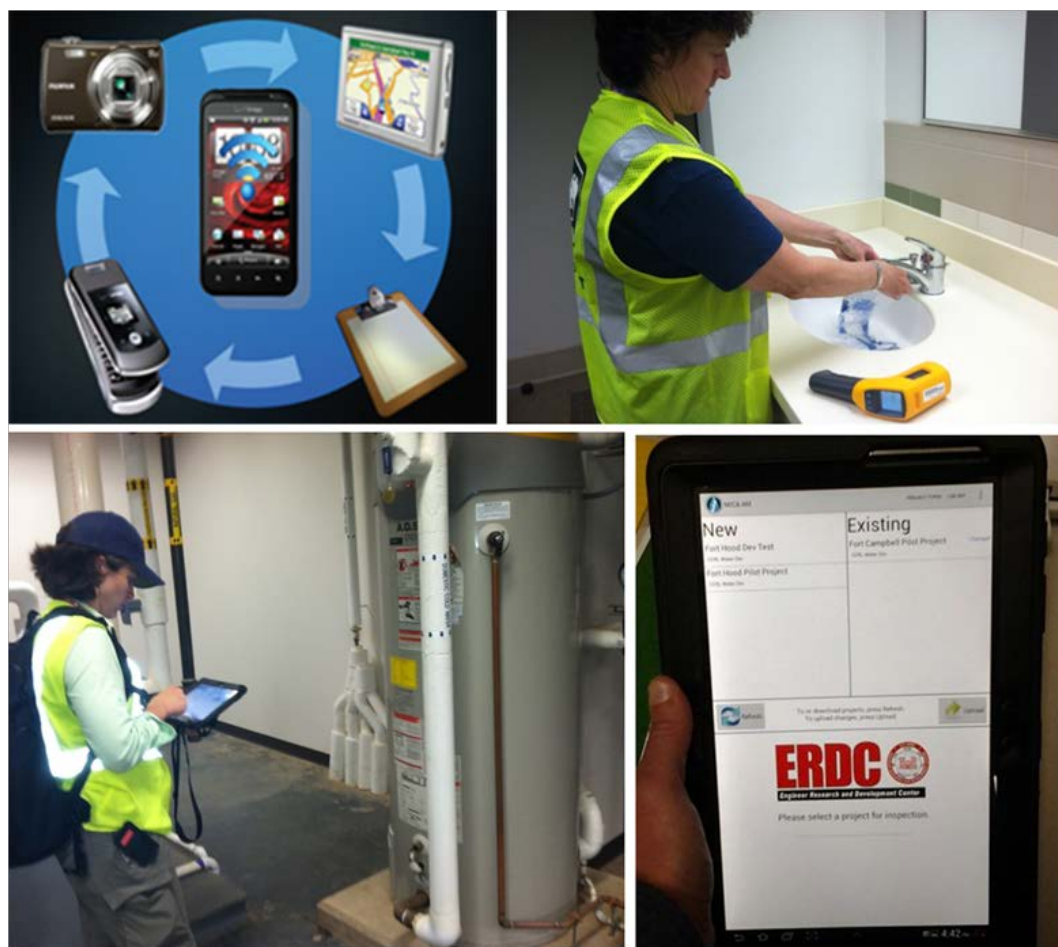
**ERDC**  
INNOVATIVE SOLUTIONS  
for a safer, better world

## Mobile Information Collection Application

Water Equipment Tracker (MICA:WET) Tool

Laura E. Curvey, Rachel Phillips, Noel L. Potts,  
James Stinson, and Eric Roth

October 2013



**The US Army Engineer Research and Development Center (ERDC)** solves the nation's toughest engineering and environmental challenges. ERDC develops innovative solutions in civil and military engineering, geospatial sciences, water resources, and environmental sciences for the Army, the Department of Defense, civilian agencies, and our nation's public good. Find out more at [www.erdcl.usace.army.mil](http://www.erdcl.usace.army.mil).

To search for other technical reports published by ERDC, visit the ERDC online library at <http://acwc.sdp.sirsi.net/client/default>.

# **Mobile Information Collection Application**

## **Water Equipment Tracker (MICA:WET) Tool**

Laura E. Curvey, Rachel Phillips, and Noel L. Potts

*Construction Engineering Research Laboratory (CERL)  
US Army Engineer Research and Development Center  
2902 Newmark Dr.  
Champaign, IL 61822-1076*

James Stinson and Eric Roth

*Information Technology Laboratory  
US Army Engineer Research and Development Center  
Waterways Experiment Station  
3909 Halls Ferry Rd  
Vicksburg, MS 39180*

## **Final Report**

Approved for public release; distribution is unlimited.

## Abstract

The Mobile Information Collection Application: Water Equipment Tracker (MICA:WET) tool is an Android application ('app') that provides a comprehensive means of tracking water equipment and conservation projects at the building level across an installation. The application's underlying database was built for compatibility with the BUILDER facility life cycle management and repair system officially adopted throughout the US Department of Defense (DoD). MICA-WET enables installation personnel to collect water-related facility data on an Android-based tablet during a facility assessment. The collected data are encrypted and uploaded via public Wi-Fi, to external servers, from which authorized users have immediate access. This report describes the MICA:WET app, and its use during field tests at five installations, Fort Hood, TX, Fort Campbell, KY, Fort Leonard Wood, MO, and two Engineer Research and Development Center (ERDC) laboratories. MICA:WET data collected from two of these installations are currently being used to propose water conservation projects. MICA:WET is also being developed to create estimates for installations that lack individual facility water meters, based on building water consumption from demographic and occupancy frequency estimates.

**DISCLAIMER:** The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. All product names and trademarks cited are the property of their respective owners. The findings of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

**DESTROY THIS REPORT WHEN NO LONGER NEEDED. DO NOT RETURN IT TO THE ORIGINATOR.**

# Contents

|                                                                   |            |
|-------------------------------------------------------------------|------------|
| <b>Abstract .....</b>                                             | <b>ii</b>  |
| <b>Illustrations .....</b>                                        | <b>v</b>   |
| <b>Preface .....</b>                                              | <b>vii</b> |
| <b>1 Introduction .....</b>                                       | <b>1</b>   |
| 1.1 Background .....                                              | 1          |
| 1.2 Objectives .....                                              | 2          |
| 1.3 Approach .....                                                | 2          |
| 1.4 Mode of technology transfer .....                             | 3          |
| <b>2 MICA:WET Mobile Computing “App” .....</b>                    | <b>4</b>   |
| 2.1 Challenges .....                                              | 4          |
| 2.2 Development of app-based auditing programs .....              | 5          |
| 2.3 MICA:WET .....                                                | 5          |
| <b>3 Data Schema .....</b>                                        | <b>8</b>   |
| 3.1 EISA 2007 .....                                               | 8          |
| 3.2 BUILDER .....                                                 | 8          |
| 3.3 Net Zero Installations Tool .....                             | 8          |
| 3.4 Mobile Information Collection Application .....               | 9          |
| 3.5 MICA:WET capabilities .....                                   | 9          |
| 3.6 Security concerns .....                                       | 10         |
| <b>4 Water Audit Strategies .....</b>                             | <b>12</b>  |
| 4.1 Civilian and Federal .....                                    | 13         |
| 4.2 Micro-audits .....                                            | 14         |
| 4.3 Strategies for audits .....                                   | 15         |
| 4.4 Building water audit field team requirements .....            | 16         |
| 4.5 Water assumptions .....                                       | 16         |
| 4.5.1 NZW balance studies .....                                   | 16         |
| 4.5.2 Studies done AWWARF/Water Research Foundation Studies ..... | 18         |
| 4.5.3 US Green Building Council .....                             | 19         |
| 4.6 Conclusion .....                                              | 19         |
| <b>5 Building Level Algorithms .....</b>                          | <b>21</b>  |
| 5.1 Domestic .....                                                | 21         |
| 5.1.1 Toilets and urinals .....                                   | 23         |
| 5.1.2 Faucets and showerheads .....                               | 23         |
| 5.2 Commercial/industrial equipment .....                         | 24         |
| 5.3 Lab-medical equipment .....                                   | 25         |
| 5.4 Cooling towers .....                                          | 25         |
| 5.5 Steam boilers .....                                           | 26         |
| 5.6 Motor pool vehicle wash .....                                 | 26         |

|          |                                                                                  |           |
|----------|----------------------------------------------------------------------------------|-----------|
| <b>6</b> | <b>Field Tests.....</b>                                                          | <b>27</b> |
| 6.1      | Fort Hood, TX.....                                                               | 28        |
| 6.1.1    | 1 <sup>st</sup> Visit: <i>BUILDER</i> field coordination.....                    | 28        |
| 6.1.2    | 2 <sup>nd</sup> Visit: First tablet field test next to <i>BUILDER</i> teams..... | 29        |
| 6.2      | Fort Campbell, KY.....                                                           | 29        |
| 6.2.1    | Field Test with PNNL water audit team.....                                       | 29        |
| 6.2.2    | Field test results.....                                                          | 30        |
| 6.3      | Waterways Experiment Station, Vicksburg MS.....                                  | 30        |
| 6.3.1    | Level 1 audit at WES.....                                                        | 31        |
| 6.4      | Fort Leonard Wood, MO.....                                                       | 32        |
| 6.4.1    | First audit at large Army Installation.....                                      | 32        |
| <b>7</b> | <b>Auditing with the MICA:WET tool.....</b>                                      | <b>34</b> |
| 7.1      | Equipment list.....                                                              | 34        |
| 7.2      | Application training.....                                                        | 34        |
| 7.3      | Directions for application use.....                                              | 35        |
| 7.3.1    | Getting the project started.....                                                 | 35        |
| 7.3.2    | Screen navigation.....                                                           | 35        |
| 7.3.3    | Connecting to WI-FI.....                                                         | 36        |
| 7.3.4    | Command icons.....                                                               | 37        |
| 7.3.5    | User registration.....                                                           | 38        |
| 7.3.6    | Accessing the application on Android Store.....                                  | 40        |
| 7.3.7    | Logging in.....                                                                  | 42        |
| 7.3.8    | Upload, refresh, and updates.....                                                | 42        |
| 7.3.9    | Accessing building list.....                                                     | 45        |
| 7.3.10   | Begin auditing a building and adding child components.....                       | 47        |
| 7.3.11   | Taking photos.....                                                               | 55        |
| 7.3.12   | Making templates.....                                                            | 57        |
| 7.3.13   | Editing templates.....                                                           | 59        |
| 7.3.14   | Rooms that represent other rooms.....                                            | 61        |
| 7.3.15   | Removing child components.....                                                   | 62        |
| 7.3.16   | Irrigation.....                                                                  | 63        |
| 7.3.17   | Alternative water options.....                                                   | 65        |
| 7.4      | Accessing the data after auditing.....                                           | 66        |
| 7.5      | Next steps.....                                                                  | 66        |
| <b>8</b> | <b>Conclusion.....</b>                                                           | <b>68</b> |
|          | <b>Acronyms and Abbreviations.....</b>                                           | <b>69</b> |
|          | <b>References.....</b>                                                           | <b>71</b> |
|          | <b>Appendix A : Supplemental Sources.....</b>                                    | <b>73</b> |
|          | <b>Appendix B : NZI Tool Screen Shots.....</b>                                   | <b>78</b> |
|          | <b>Appendix C : Fort Leonard Wood Water Audit.....</b>                           | <b>80</b> |
|          | <b>Report Documentation Page (SF 298).....</b>                                   | <b>1</b>  |

# Illustrations

## Figures

|    |                                                            |    |
|----|------------------------------------------------------------|----|
| 1  | Example end-use summary for Denver (interim results) ..... | 19 |
| 2  | Tablet Home screen .....                                   | 36 |
| 3  | Step 1, Registration.....                                  | 38 |
| 4  | Step 2, Registration.....                                  | 39 |
| 5  | User permissions.....                                      | 40 |
| 6  | Airwatch App on Google Play .....                          | 41 |
| 7  | Search for Army App on Airwatch .....                      | 41 |
| 8  | Logging in .....                                           | 42 |
| 9  | Uploading data.....                                        | 43 |
| 10 | Refreshing data .....                                      | 44 |
| 11 | Updating App.....                                          | 45 |
| 12 | Project List.....                                          | 46 |
| 13 | Building list .....                                        | 46 |
| 14 | Building level fields.....                                 | 47 |
| 15 | Selecting Type of Buildings level fields .....             | 48 |
| 16 | Adding child component.....                                | 49 |
| 17 | Adding a floor, .....                                      | 50 |
| 18 | Adding a floor level .....                                 | 50 |
| 19 | Adding data to a floor level.....                          | 51 |
| 20 | Adding a room level .....                                  | 52 |
| 21 | Adding room level data .....                               | 53 |
| 22 | Adding fixture data .....                                  | 54 |
| 23 | Fixture data fields .....                                  | 54 |
| 24 | Adding data to fixture level.....                          | 55 |
| 25 | Taking a photo.....                                        | 56 |
| 26 | Adding comments.....                                       | 57 |
| 27 | Adding templates.....                                      | 58 |
| 28 | Selecting a template .....                                 | 59 |
| 29 | Editing a template at fixture level .....                  | 60 |
| 30 | Editing a template at any level.....                       | 60 |
| 31 | Selecting a template .....                                 | 61 |
| 32 | Rooms that represent other rooms.....                      | 62 |
| 33 | Removing a component.....                                  | 63 |
| 34 | Adding irrigation.....                                     | 64 |

|    |                                                                                                              |    |
|----|--------------------------------------------------------------------------------------------------------------|----|
| 35 | Types of data .....                                                                                          | 65 |
| 36 | Adding alternative water .....                                                                               | 66 |
| A1 | Differences between piston and diaphragm valves .....                                                        | 74 |
| B1 | Draft screen for NZI Tool, study information, details (includes soil type and evapotranspiration [ET]) ..... | 78 |
| B2 | Draft screen for NZI Tool, study information, details (soil & ET pull-down menus) .....                      | 78 |
| B3 | Draft screen showing study utilities with water and waste included .....                                     | 79 |
| B4 | Draft screen for NZI Tool, study information, utilities (including water) .....                              | 79 |

## Tables

|    |                                                                    |    |
|----|--------------------------------------------------------------------|----|
| 1  | TWDB water balance.....                                            | 13 |
| 2  | AWWA breakout of real losses (cf. Tbl. 1).....                     | 13 |
| 3  | PNNL fixture use assumptions .....                                 | 17 |
| 4  | AWWARF 1999 fixture use assumptions .....                          | 17 |
| 5  | USGBC residential fixture use assumptions.....                     | 20 |
| 6  | Number of days to estimate yearly demand.....                      | 22 |
| 7  | Daytime use assumptions.....                                       | 22 |
| 8  | Morning/evening use assumptions .....                              | 23 |
| 9  | Evaporation rate correction factor.....                            | 25 |
| C1 | Fort Leonard Wood schedule for water audit (6/25/13–6/27/13) ..... | 80 |

## Preface

This study was conducted for the Office of the Assistant Secretary of the Army for Energy and Sustainability under project order #396378, “Water Equipment Tracking Tool.” The technical monitor was Dr. Marc Kodack, Office of the Assistant Secretary of the Army (Installations, Energy, and Environment) (ASA[IE&E]).

The work was performed by the Energy Branch (CF-E) of the Facilities Division (CF), US Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL). The CERL principal investigator was Laura E. Curvey. Part of this work was completed by Rachel Phillips and Noel Potts.

The coding and creation of the application would not be possible without the work of James Stinson and Eric Roth of ERDC’s Information Technology Lab (ITL). The incorporation of an essential web interface for database and ITL server access was made possible through collaboration and support from Dr. Mike Case’s Environmental Security Technology Certification Program (ESTCP) supported Net Zero Installation Tool research project. Invaluable algorithm and input design was provided by Kate McMordie-Stoughton and Bryan Boyd of the Pacific Northwest National Laboratory (PNNL). Essential data schema compatibility design collaboration was possible with the generous help of Michael Grussing and Lance Marano of the BUILDER program.

Special appreciation is owed to the installations and other Points of Contact (POCs) for providing information and access that was invaluable to this study and for reviewing this report. These individuals are: Nathan Raine and Robert Millanback of Fort Hood, Robert Baldwin of Fort Campbell, Cynthia Ray and David Rogillio at ERDC’s Waterways Experiment Station, Bryan Parker at Fort Leonard Wood. Fort Leonard Wood POCs for data and coordination for entry into buildings were: Dennis Kiska (Barracks), William Moffitt (DFAC), Bryan Parker (Administrative and Industrial), and Mr. William (Recreational and Indoor Pools). Auditing students and app interface feedback were performed by Susan Bevelheimer, Marianne Choi, Noah Garfinkle, and Sarah Nemeth of ERDC-CERL.

At the time of publication, Franklin H. Holcomb was Chief, CEERD-CF-E and L. Michael Golish was Chief, CEERD-CF. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti and the Director was Dr. Ilker Adiguzel.

COL Jeffrey R. Eckstein was the Commander of ERDC, and Dr. Jeffery P. Holland was the Director.

# 1 Introduction

## 1.1 Background

The US Army is vulnerable to the same issues of water supply and demand that jeopardize water security globally; it is growing increasingly difficult to provide required amounts of clean fresh water in locations where it is needed. Conditions that exacerbate the increasingly limited availability of water are the aging condition of water infrastructure, generalized population growth, especially in regions containing key Army installations, increased water demands for energy generating processes, and uncertain, but generally agreed on, regional effects of global climate change.

Over the past decade, these global drivers have stimulated the creation of Federal legislation and executive orders that stipulate increasingly rigorous water conservation requirements. Executive Order (EO) 13342 and EO 13514 require Federal agencies to establish baselines for potable water consumption using FY07 as a baseline, and to reduce water intensity by 2% per square foot annually through 2020. Section 432 of the Energy Independence and Security Act of 2007 (EISA 2007) requires Federal agencies to “complete, for every calendar year, a comprehensive energy and water evaluation for approximately 25% of the covered facilities\* in a manner that ensures the installations is evaluated every four years” (EISA 2007, Section 4, Paragraph A). EISA 2007 Section 432 also requires the creation of a Compliance Tracking System (CTS) to track the progress and performance of Federal agencies’ energy and water evaluations.

To meet these requirements, installation energy managers and Directorate of Public Works (DPW) personnel must:

- Establish a regular and continuous Level 1 audit program to track the required data. Level 1 audit data can be collected through two methods: (1) by an assessment of existing documents, or (2) through physical and visual inspection to gain basic information about a facility. Audit levels are defined as: Level I – Walk-Through Analysis, Level II – En-

---

\* i.e., any building, installation, structure, or other property greater than 50,000 sq ft owned or operated by the Federal Government

ergy Survey and Engineering Analysis, and Level III – Detailed Analysis of Capital-Intensive Modifications (Underwood et al. 2010).

- Perform room-by-room evaluations and inventories of energy and water use throughout every Federal facility.
- Report the results of the audits to the CTS.
- Based on evaluations of their systems, plan energy- and water-saving projects.

This is a significant change from current practice at Army installations. Some energy managers depend on contractors or other Federal agencies to perform whole or targeted audits of their facilities once every 5 or 10 years. Otherwise, most of the working knowledge of their inventories is not tracked. Energy and water managers commonly work from memory and plan projects as the opportunity to upgrade or maintain facilities present themselves.

There is a need for an easy-to-use tool and associated database that can track water conservation projects and equipment at the building level. This work was undertaken to develop the MICA:WET tool to fill this need and to outline training that will enable installation managers, planners, and modelers to use MICA:WET to meet the requirements of EISA 2007, Section 432.

## **1.2 Objectives**

The objectives of this work were to:

1. Develop the MICA:WET tool to help installation managers, planners, and modelers track water conservation projects and equipment at the building level, to meet the requirements of EISA 2007, Section 432.
2. Outline training to enable installation personnel to use MICA:WET.

## **1.3 Approach**

The objectives of this work were accomplished in the following steps:

1. A literature survey of existing building level auditing strategies and assumptions was conducted.
2. It was determined that, for future database relevancy, MICA:WET's schema design should be compatible with BUILDER's schema to allow data integration. The compatibility allows for future data integration between the two.

3. After a schema was designed, it was then tested at Fort Hood and Fort Campbell, and feedback was solicited from Pacific Northwest National Laboratory (PNNL) field auditors.
4. The results of the testing and solicited feedback were used to revise and improve the user interface and algorithms.
5. As the test data were collected, it was determined that it was possible to calculate building level demand. The schema was changed to accommodate the necessary inputs.
6. Audits were also conducted at two additional installations, the Waterways Experiment Station (WES), Vicksburg, MS, and Fort Leonard Wood, MO. These results of these audits were used to test and verify the tool's interface, and its capabilities for data merging, updates, uploads, web portal linkage, and data downloads.
7. Testing of the algorithms for building level demand is ongoing.

## **1.4 Mode of technology transfer**

Access to data collected with this application can be downloaded from <http://134.164.53.44/nzie/> after registration with ITL.

This report will be made accessible through the World Wide Web (WWW) at URLs: <http://www.cecet.army.mil> and <http://libweb.erdclib.usace.army.mil>

## **2 MICA:WET Mobile Computing “App”**

### **2.1 Challenges**

To meet the requirements of EISA 2007, Section 432, installations must overcome manpower and training limitations. Energy and water audits currently involve slow, labor intensive processes. Auditors or evaluators must be formally trained to perform the audits and compile the data for analysis. An EISA 2007 training development and compliance project (Josefik 2013) found that the training of personnel to do traditional energy audits of their facilities requires a minimum of 4 days; new auditor trainees take anywhere from 2 hours to a full day per building to capture required audit data needed for the Facility Energy Decision System (FEDS) input. During training, the study found that newly trained personnel often forget to capture all the required data using paper forms. This training collected data using paper forms and clipboards, a method common to most audits. New auditors using this method were seen to lose data, to miss inputs, and to introduce errors either during entry on the forms and/or when transferring data from the forms to the computer systems. Such errors may prevent the calculation of energy cost savings and demand (Kelsey Johnson, interviewed 3 June 2013).

An alternative to traditional, paper-based audits is to perform audits by entering data directly into mobile electronic tablets. Although personnel must also be trained in the use of mobile electronic tablets, this technology and MICA:WET offer several distinct advantages. Mobile tablets may be preloaded with preset forms where they can notify auditors if they are missing information required necessary to calculate demand or savings. Many tablets have built in cameras that give apps such as MICA:WET the capability to embed and organize photos automatically associated with specific buildings, floors, and equipment. Auditing apps can also be designed to fill forms, create reports, and summarize building level or installation level data. The use of mobile tablets also simplifies auditing by eliminating the need to carry additional equipment such as cameras, notebooks, forms, and pens. Additionally, apps may be designed to automatically create a database to which multiple auditors can contribute separately or simultaneously; this connectivity improves data quality and eliminates the added effort to compile and transfer notes from multiple

manually created audits. The combination of these features can potentially save up to 75% in audit costs by eliminating transfer errors and reducing the time needed for data entry from paper forms into a computer database\* (Macumber 2013).

## 2.2 Development of app-based auditing programs

As mobile computer technology has improved, app-based audits have become available through the Internet. Several basic energy and water audit programs are available on home computers and a growing number of energy audit apps for government use are becoming available for tablets. However, not many comprehensive water equipment audit apps are commercially available (e.g., through the I-store, the Android catalog, or military apps catalogs). Some private companies provide software designed to custom make apps for any tablet type. For example, *FOAudits* (Fundamental Audits, Inc. 2013) provides the capability to create custom energy and water audit tools, but the civilian program maintains the input data.

Some emerging Federal-based efforts have begun to create auditing applications. An ongoing Environmental Security Technology Certification Program (ESTCP) project (Macumber 2013) funded the creation of an energy audit application for mobile tablets that is focused on enabling Federal agencies to meet EISA 2007 energy audit requirements. However, most existing water audit tools designed for mobile tablets are proprietary, municipal focused, and require the contractor to perform the audits (Maddaus 2012).

## 2.3 MICA:WET

Two Engineering Research Development Center (ERDC) laboratories, the Construction Engineering Research Lab (CERL) and the Information Technology Laboratory (ITL), collaborated to create the Water Equipment Tracker (WET) tool using the existing ITL Mobile Information Collection Application (MICA) framework. The resulting application became known as “MICA:WET,” a water audit application designed to enable Federal agencies

---

\* Current Level I/II audits = \$0.10 - \$0.15/sq ft. Level III audits currently = \$0.26- \$0.35/sq ft  
Using mobile tablets: \*75% reduced Level III audits = \$0.07 - \$0.09/sq ft. It is possible to get Level III audits for less than the currently cost of Level I/II audits. Current Level I / II audits - 75% reduced Level III audits = Savings = \$0.03 - \$0.06/sq ft (Macumber 2013).

to meet the comprehensive water audit requirements of EISA 2007, while satisfying their special needs for design, standardization, and security.

The MICA:WET tool can be used to capture information pertaining to existing water equipment throughout an installation. MICA:WET allows auditors to quantitatively measure flow rates and photographically inventory existing equipment throughout an installation. The collected data are then wirelessly transmitted to a central server located at ITL. Available calculations estimate yearly or daily water demand at the building level based on estimated daily occupancy, time of use throughout the day, and demographics. The coding and testing of the algorithms were still in progress.

MICA:WET is designed to be compatible with two established management and optimization programs: BUILDER (ERDC-CERL 2007) and the Net Zero Installation (NZI) Tool (USAASC 2011). Data collected by MICA:WET are uploaded via Wi-Fi networks to the Research and Development Network Servers at ITL. Registered users of the NZI Tool can then download and use their data to plan efficiency and conservation measures.

Military installations generally do not have individual facility water meters. If water is purchased from a supplier, an entire installation may have only one meter located on the main potable water system where it enters the installation. This creates a challenge for operators, to disaggregate the data from the installation level meter to determine where water demand can be reduced. With finalized algorithms coded into the app, MICA:WET will be able to estimate building level water use and then combine those estimates into a model of overall water use at the installation level. When the algorithms are refined through additional testing, the MICA:WET tool will be useful in determining tenant use until individual meters and/or sub-meters are installed.

In addition to being an easily revised database designed for compatibility with existing management systems, MICA:WET also provides operators access to data in Excel® spreadsheet format. MICA:WET will also provide planners and modelers accurate installation-wide indoor and outdoor summaries of buildings and their standard water equipment.

Currently, most of the information used for water modeling and planning is stored in separate agencies, unshared, and too often forgotten by water and utility staff. As a relevant and adaptable database, the MICA:WET tool

can serve as a time saving field audit, data collection and storage, and inventory analysis tool. The MICA:WET tool tracks water-related equipment at the building level, and collects and stores that information in an easily usable database that installation operators can use to document existing (and estimate future) water demand. Once established, MICA:WET will provide a one-stop reference for water data that will serve as an easy source for updated equipment on subsequent iterations for planning models such as the Decision Support System (DSS) model or other appropriate planning tools.

## **3 Data Schema**

The MICA:WET app's data organizational design is essential to ensure its relevance. From the beginning, the data schema was designed to meet EISA 2007 standards, to easily fit into existing data frameworks, and to be compatible with BUILDER's life cycle maintenance management system and with the NZI Tool.

### **3.1 EISA 2007**

EISA 2007, Section 432, subsection 4 gives guidance regarding required comprehensive energy and water evaluations. Specifically, EISA 2007 stipulates annual comprehensive energy and water evaluations of 25% of covered facilities to ensure that all covered facilities are evaluated once every 4 years). Although most of the detailed guidance in Section 432 focuses on energy, water evaluations are also required. MICA:WET was designed to capture the existing condition of water fixtures to enable facilities managers to meet the requirements for Level 1 water auditing required by EISA 2007.

### **3.2 BUILDER**

BUILDER is an Engineered Management System (EMS), developed by ERDC-CERL that uses life cycle engineering to help facility managers to determine the physical condition of facilities, to determine their maintenance and repair requirements, and to plan project priorities (ERDC-CERL 2012). BUILDER has been widely adopted throughout US Department of Defense (DoD) and is in varying stages of adoption in the Service branches, the Defense Logistics Agency, and the Tri-care Medical Agency. The Deputy Undersecretary of Defense, Installations, Environment (DUSD, I&E) is likely to recommend BUILDER as the facility rating standard for the all DoD. To increase its relevancy, MICA:WET is designed to be compatible with BUILDER and can provide data to BUILDER on request through the database infrastructure built by and for the Net Zero Installations Tool (NZIT) project.

### **3.3 Net Zero Installations Tool**

The Net Zero Installation Tool, an ongoing ESTCP project in ERDC-CERL (USAAASC 2011), focuses on combining net zero planning for energy, wa-

ter, and solid waste together into an overall modeling and planning tool for installations (NZIT). This tool is being designed to capture energy, water, and waste activities from the building level up to the regional level. Such information might, for example, be useful in determining how an energy conservation measure might affect an installation's demand for water, or its production of waste. As part of this project ERDC-CERL has been working closely with the ERDC-ITL lab in Vicksburg, MS. This collaboration has established a server infrastructure which MICA:WET is now using, paralleling the data collected and feed into the NZIT modeling data schema. In turn, MICA:WET's data are available through the same web interface created for NZIT. The interface provides a means for installations to download Excel<sup>®</sup> versions of the data collected during audits.

### **3.4 Mobile Information Collection Application**

The MICA program, based at ITL in Vicksburg, MS, is a program that supports several field applications designed for civil and coastal engineering auditing requirements. The MICA framework supports the WET tool by providing a database infrastructure and server support. As a result of CERL's ongoing collaboration with ITL on the ESTCP NZIT project, MICA now provides a way to connect the WET to existing MICA infrastructure.

### **3.5 MICA:WET capabilities**

MICA:WET's interface and database are organized similarly to those of BUILDER. In both applications, the user progressively "drills down" from the entire facility to smaller components, from the installation as a whole, to the facility, to the floor, to the room, and then finally to an individual piece of equipment or fixture. The collected data are organized into a series of tabbed pages. The first "summary" tab shows the building level and summary water demand and fixture numbers. Following the summary page are tabs for fixture level data, with a tab dedicated to each equipment type so that trends among fixtures can be organized and analyzed. Chapter 6 of this report includes screen shots of the interface, and Appendix B gives examples of web interface and data downloads.

The MICA:WET application also has the capability to capture photos at each audit stage to capture building, equipment, and locations. These photos are stored and co-located to their respective level within the application. For example, an auditor may take a photo of a building "Y" that will be stored at the building level of the application and take a photo of a fau-

cet in room “X.” That photo will be associated with room “X” and building “Y.” This improves on existing practices, which require the auditor to carry a camera in addition to a clipboard such that each photo then needs to be numbered for later reference. This extra effort may cause confusion if the numbers are not written correctly, or if another analyst takes the data and is unable to read the field auditors writing.

Some mobile applications do have the capacity to do simple calculations within the application on the tablet. Currently, MICA:WET does not have this capability. It is currently just a data gathering application with the building level water demand estimates performed within the servers at ITL. The data from the tablet go into a spreadsheet that has preloaded formulas for building level calculations. It is then automatically connected to the water data page of the NZIT web interface. The data are then transferred into an Excel<sup>®</sup> spreadsheet along with the formulas for the algorithms. After the calculations are performed, the spreadsheet is linked to the NZIT website for download. Installation facilities managers must register to gain access to the website. Many additional tools are available to registered users to perform “what-if” analyses as part of their planning efforts. The water data are located on the Water Data tab on the web site and are available for downloading.

Future revisions to the current MICA:WET, version 1.0, could expand its capabilities to include the ability to perform calculations within the application, and to include geo-spatial data of the installation with water demand estimates for buildings. Currently, both of these capabilities are being coded to work within the NZIT web interface so facility managers will still be able to access and view the data on their personal computers after the collected data are uploaded to ITL’s servers.

### **3.6 Security concerns**

The availability of multiple mobile tablets, the growing number of applications available for use in the military, and employees’ desire to use them have given rise to security concerns about protecting the data, particularly from physical theft of the tablet. During the infancy of this project, ERDC instituted a moratorium on the use of all mobile tablets as a result of this concern. During the moratorium, ERDC worked to enforce, implement, and install security programs on each mobile device so that if they were stolen, the tablets could be remotely erased. As mobile tablets become available for government employees, additional training is required to en-

sure that all users are fully aware of the risks involved with using government smartphones and tablets. For example, the Defense Information Systems Agency offers on-line training on how to secure smartphones and tablets: [http://iase.disa.mil/eta/smartphone\\_tablet\\_v2/launchpage.htm](http://iase.disa.mil/eta/smartphone_tablet_v2/launchpage.htm)

The tablets are considered research and development (R&D) equipment and are therefore unable to connect directly to installation network systems. The method for uploading tablet data to ITL servers is done remotely either via cellular or available Wi-Fi and should be done with approved government Wi-Fi hotspots or wireless systems. Data from the tablets are encrypted during uploads and are still secure regardless if the upload occurs in a public location. However, care should be given and data should be uploaded either via verified private networks (VPNs) or government wireless locations. Most installations have limited, if any, Wi-Fi locations. Thus, auditors will likely have to find government approved Wi-Fi hotspots to upload data from their daily data collection. The data are uploaded to a secure (R&D) server at ITL. Access via ITL server is available through ITL personnel and subsequently to the NZIT web interface available on the Internet. Facilities managers can then access their data through the NZIT, which can access the secured ITL server.

If MICA:WET were to be used at contingency bases, security concerns may require the collected data remain on the tablets until they can be uploaded at approved Wi-Fi or cellular locations.

## 4 Water Audit Strategies

Water audits can range from a macro view of water use to a micro view. Methods for the macro view focus on utility level input and outputs of an entire system, i.e., on overall authorized consumption, and on real and apparent losses, to discern total volume and cost of lost non-revenue water. At the utility level, the American Water Works Association's (AWWA's) water audit strategies focus on "tracing the flow of water from the site of water withdrawal or treatment, through the water distribution system, and into customer properties" (AWWA 2012).

AWWA has provided its members with a free Excel® based water audit software designed to help utility managers understand the extent of their non-revenue losses (AWWA 2012) that essentially summarized and captured a utility level water audit. If an installation has a comprehensive metering program that captures end-use throughout the facility, it may refer to the AWWA website (<http://www.awwa.org/>) to download the Excel® water audit software. The spreadsheet gives step by step instructions and definitions regarding the inputs to determine overall losses. Another utility level source to consider is Texas Water Development Board (TWDB) Report 367, *Water Loss Audit Manual for Texas Utilities* (Mathis, Kunkel, and Howley 2008), which complements the AWWA worksheet and general format. TWDB Report 367 is an excellent reference for audit methods and for validating consumption and loss data.

AWWA and TWDB use the term "water balance" to capture all the water accounted for during an audit. The water balance figuratively shows how "all the quantities of water fit into one of the boxes of the water balance. The sum of the quantities of each column in the water balance is the same; hence, all quantities balance" (TWDB 2008). The AWWA and TWDB tools use nearly identical classification tables that break out water balances (Tables 1 and 2) using a macro water audit method (Mathis 2008).

**Table 1. TWDB water balance.**

|                          |                        |                                 |                                  |                   |
|--------------------------|------------------------|---------------------------------|----------------------------------|-------------------|
| Corrected input volume   | Authorized consumption | Billed authorized consumption   | Billed metered consumption       | Revenue water     |
|                          |                        |                                 | Billed unmetered consumption     |                   |
|                          |                        | Unbilled authorized consumption | Unbilled metered consumption     | Non-revenue water |
|                          |                        |                                 | Unbilled unmetered consumption   |                   |
| Wholesale water imported | Water losses           | Apparent losses                 | Unauthorized consumption         |                   |
|                          |                        |                                 | Customer meter under-registering |                   |
|                          |                        |                                 | Billing adjustment and waivers   |                   |
|                          |                        | Real losses                     | Reported leaks                   |                   |
|                          |                        |                                 | Unreported leaks                 |                   |

**Table 2. AWWA breakout of real losses (cf. Tbl. 1).**

|             |                                                                |
|-------------|----------------------------------------------------------------|
| Real losses | Leakage on transmission and distribution mains                 |
|             | Leakage and overflows at utility's storage tanks               |
|             | Leakage on service connection up to point of customer metering |

AWWA's water balance audit table is almost identical to TWDB's except for two columns. AWWA assumes that its System Input Volume is already corrected for known errors, whereas the TWDB audit delineates between the two as part of its system of classification. In addition, AWWA breaks real losses into three specific location categories (Table 2), whereas TWDB breaks real losses into two categories (reported leaks and unreported loss). The utility manager must decide how to classify and quantify real losses, and possibly how to further itemize any one of these categories.

#### **4.1 Civilian and Federal**

These standard utility level water audits are designed based on the assumption that a utility depends on revenue from billed water customers, which is not the case on most Federal installations. Until EO 13514 required all Federal facilities to reduce water intensity by 26% per square foot by 2020, using FY2007 as a baseline, most Federal installation did not track water supply or consumption. The potable water distribution systems on many installations leak, but without meters or current leak detection surveys, the extent of these leaks is unknown.

Even though it is assumed that leaks account for real losses of 5 to 20%, water use may only be tracked from the main meter to calculate water intensity for the entire installation. Except for water use by some reimbursable customers, the vast majority of consumption throughout military in-

stallations, such as housing, barracks, training ranges, and vehicle washes, is not metered. This limits the reliability of utility data available to macro level water audits on military installations.

By contrast, labor intensive building, irrigation, and special end-use level audits are required to estimate and to account for supply from the ground up and where the supply could be going in the installation. Micro-audits, performed over time, enable the creation of installation-wide water balances.\* Only from the accumulation of end-use micro-audits are installation-wide water balances possible.

Revenue on installations from reimbursable customers is often based on a set rate per square feet, not on actual metered use. Although that practice is changing to one that manages reimbursable demand by metering water use and charging based on a tiered water rate structure, this change has not yet been fully implemented. The Department of the Army (Chief of Engineers 2012) has provided recent guidance for installations on how to design rates for metered reimbursable customers, which details how to create a rate structure, including the extent an installation can charge reimbursable customers based on available water resources and their costs.

## 4.2 Micro-audits

For more focused building level audits and end-use water balance calculations, municipalities still require historical data from the local water utility. Such audits also focus on building equipment to understand the disaggregation at the user level and whether there is potential for cost effective efficiency upgrades. A comprehensive view of a community's water use requires a holistic review of the overall supplied water compared to the overall metered consumption and a comparison of building level consumption patterns to tailor conservation measures for specific customers. The use of meter data, flow recorders, and even appliance level meters will help to determine and separate use patterns to reflect the concentration of domestic, industrial, and even outdoor water use. However, without meter data, assumptions have to be made and combined with existing standards, measured flow rates, and demographics. It is unclear which assumptions are the most accurate.

---

\* Micro-level audits can be considered audits at the facility- or specialized end-use-level; specialized end-uses include, for example, golf courses, vehicle wash, industrial uses, medical facilities, or irrigation.

Creating a water balance, beginning with individual building data and then increasingly aggregated data beyond the single building all the way up to an entire installation, requires accurate use data and as few assumptions as possible. Recent PNNL studies (McMordie-Stoughton 2012) created water balances for eight Army net zero water (NZW) pilot installations. Each installation had only limited building level meter data, although each had overall historical supply data for roughly 4 to 10 years. PNNL's methods focused on building level audits across a sample of building types and age groups within an installation. PNNL then used demographic and daily use patterns within each building type or end-use to extrapolate major water uses across the entire installation.

### 4.3 Strategies for audits

Both macro and micro-scale audits require historical data. The macro-scale audit compiles the known meter data and compares it to the known supplied volume from the utility. The micro-scale audit typically focuses on groups of buildings and the equipment within those buildings. Information gathered before conducting an onsite-audit typically requires:

- water and sewer bills –previous full year (note rate structures)
- water meter sizes and locations
- all sources of potable and nonpotable water
- process sub-metering data
- wastewater treatment
- production flow diagrams
- plumbing diagrams
- irrigation drawings and controls
- number of employees/users/customers
- shifts, work, and clean-up schedules
- products and services
- production rates/occupancy
- list of known water-consuming processes and uses
- prior water or energy surveys
- maintenance schedule info (Albrecht 2010).

The following steps combine suggested processes from Waste Reduction Partners (Albrecht 2010):

1. Confirm client's/installation's commitment
2. Assemble the audit team
3. Collect background information

4. Conduct an onsite water audit
5. Assemble tools and take measurements (Chapter 6 and Appendix A)
6. Perform a water balance
7. Calculate the true cost of water
8. Identify target areas for efficiency
9. Prepare report/recommendations
10. Follow-up.

#### **4.4 Building water audit field team requirements**

To conduct water audits, field teams will need access to mechanical rooms, private barrack rooms, and medical and dining facilities. They will be measure flow rates, annotate appliances types, take equipment photos, and interview building Points of Contact (POCs) to understand occupancy schedules, demographics of occupants, and number of occupants. For the sake of efficiency, a public works person or a unit building POC should be available to give access to mechanical rooms, barracks rooms, and commercial processes as needed. To capture how a building is being used, it is essential that auditors either have a working knowledge of the building, or that they have access to a building POC who can provide that knowledge to collect accurate building level demographic and occupancy data.

#### **4.5 Water assumptions**

##### **4.5.1 NZW balance studies**

In 2012 and 2013, PNNL created water balances for eight NZW pilot locations using building level audits and interviews. Much of the demand assumptions at different buildings were made based on demographic data, occupancy, and fixture measurements (Boyd et al. 2012).

Water consumption at the end-use level was estimated using typical use patterns for equipment type or based on information gathered during walk-through audits at the facilities. Some of the assumptions used in the PNNL water balance assessments varied because a few of the assessments were subcontracted to water management firm that used an internal model for end-use estimating (see Appendix A of Boyd et al. 2012). Much of the data pertaining to industrial uses were based on interviews or actual meter readings and use data. However, as is the case for most military installations, water use at residential, barracks, and administrative buildings was estimated based on assumptions.

While they all followed the same method to perform their water audits, their assumptions on daily use of plumbing fixtures differed. Different sets of estimates often differed from the metered supply. Differences varied from 2 to 44%, with an average of 21%. These differences reflect the challenges of doing a ground-up approach, and the challenges that result from conditions in which end-use data are inaccessible for audits. While the fact that the estimates are based on different assumptions may explain their disparity, it does not address the more important question: Which set of plumbing end-use assumptions more accurately reflect how people use water on military installations? It will be difficult to answer this question until actual meter data becomes available for comparison.

PNNL auditing teams based their plumbing fixture assumptions (Table 3) on numbers of use per day or night (Boyd et al. 2012) according to Vickers (2001), or on the American Water Works Association Research Foundation (AWWARF) 1999 and 2000 studies on residential, commercial, and institutional end-use assumptions (Table 4), which base use on the number of hours per day an occupant is estimated to be within a building (Elam 2012a, 2012b, 2012c).

**Table 3. PNNL fixture use assumptions.**

| Category                                                   | Fixture Type | Assumption                             |
|------------------------------------------------------------|--------------|----------------------------------------|
| Daytime male toilet use                                    | Toilet       | 1 use per day during an 8-hr work day  |
| Daytime female toilet use                                  | Toilet       | 3 uses per day during an 8-hr work day |
| On-post military male toilet use in barracks (no urinal)   | Toilet       | 3 uses per day                         |
| On-post military male toilet use in barracks (with urinal) | Toilet       | 1 use per day                          |
| Source: Vickers (2001).                                    |              |                                        |

**Table 4. AWWARF 1999 fixture use assumptions.**

| Category                             | Fixture Type  | Assumption                       |
|--------------------------------------|---------------|----------------------------------|
| Daytime male toilet/urinal use       | Toilet/urinal | 1 use per 2 hrs                  |
| Daytime male urinal use              | Urinal        | 75% of use (if available)        |
| Daytime female toilet use            | Toilet        | 1 use per 2 hrs                  |
| Lavatory faucet use (nonresidential) | Faucet        | 6 seconds per use                |
| Lavatory faucet use (residential)    | Faucets       | 5 minutes per day                |
| Kitchenette faucet use               | Faucet        | 2 minutes per day (if available) |
| Shower use                           | Shower        | 8 minutes per day (if used)      |

Although the two methods sound similar, their assumptions for urinal use by a male differ from using a urinal three times/day with one toilet use/day (Vickers 2001) to using a toilet or urinal once every 2 hours, or potentially eight times/day, assuming 10 hours spent in the barracks and 10 hours at work (AWWARF 1999, 2000). There are other nuanced differences in their assumptions of other end-uses, but without metered data, it is difficult to determine which set of assumptions provides a better estimate.

#### **4.5.2 Studies done AWWARF/Water Research Foundation Studies**

The 1999 and 2000 studies on water end-use by AWWARF are often considered by most utility managers as the most authoritative estimates. However, these studies may not be the most accurate reference for military installations. These studies focused on municipal type uses and did not cover barracks or industrial uses, such as tactical vehicle washing at military installations. Moreover, these studies are now over a decade old. Since they were published, the average per capita use fell between the years 2000 and 2005 even though the population and economy grew. This reduction may be due to increases in water use efficiency, and possibly to changes in patterns of use (Pacific Institute 2009).

The Water Research Organization, formerly AWWARF, is in the process of determining new water end-use patterns for residential locations. They are in their third year of updating the 1999 study for residential end-uses. Their interim results, which used Denver as an early example, indicate that end-use (measured in gal/house/day) has fallen significantly (Figure 1). For example, at the fixture level, faucets level were down 21%, showers were down 9%, and toilet demand was down 29% (Water Research Organization 2013). These significant changes in Denver's water use suggest that fixture efficiency is affecting typical demand, and/or that use patterns may have changed. Thus, general estimates of water use probably also need to be updated. Updated numbers and frequency of uses per day are unavailable. The Water Research Foundation study will be completed in 2014 (Water Research Foundation 2013).

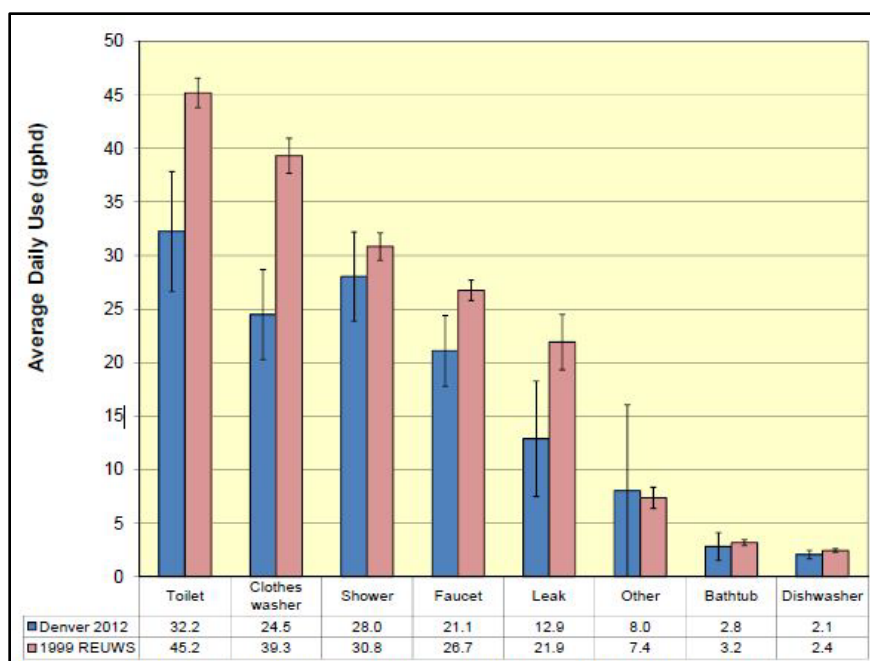


Figure 1. Example end-use summary for Denver (interim results).

### 4.5.3 US Green Building Council

For efficiency performance calculations, the US Green Building Council (USGBC) uses a different set of daily uses to size potable and nonpotable water systems. The USGBC assumptions provide guidance on sizing systems for residential and nonresidential customer use throughout a day. They assume men and women will use the restroom urinal or toilet a total of five times per day (USGBC 2012) (Table 5). The USGBC also makes differing assumptions on duration of showers and faucet use. Although the assumptions are only slightly different at the individual level, the differences could be substantial after aggregation when making estimates of demand across an installation.

## 4.6 Conclusion

Whether they are conducted from the top-down or bottom-up, water audits require enormous amounts of data to compile and then interpret aggregated information. When meter data are unavailable, the ground-up (i.e., end-use) approach requires more man-hours and field work to compile estimates. Until military installations institute standard water meter programs, assumptions will be required to disaggregate the macro data for analysis. It may take 10 to 15 years to implement comprehensive water meter programs and analysis throughout the Army. However, the Army cannot wait that long to make important water-saving and planning deci-

sions. Until meter programs can be fully implemented, the various assumptions used to estimate daily water use must be verified and tested. The MICA:WET tool provides a quick way to collect field data and apply one or more of these assumptions to estimate daily consumption (see Chapter 4).

**Table 5. USGBC residential fixture use assumptions.**

| Fixture Type          | Duration (seconds) | Uses/Day |
|-----------------------|--------------------|----------|
| Water closet (female) | N/A                | 5        |
| Water closet (male)   | N/A                | 5        |
| Lavatory faucet       | 60                 | 5        |
| Shower                | 480                | 1        |
| Kitchen sink          | 60                 | 4        |

## 5 Building Level Algorithms

As MICA:WET was being developed, it became obvious that the next step, after the data were collected, would be to combine the collected data with the coded algorithms. Initially, the algorithms were written in C++ within the ITL server rather than using macros in an Excel spreadsheet that could be downloaded from the web portal. However, it was found that coding the algorithms using Excel macros actually worked better. Consequently, the algorithms to be tested for MICA:WET were built into the Excel spreadsheets to be downloaded from the NZIT servers. CERL and ITL continue to work on the algorithms. Eventually, when facilities managers access the website, they will be able to download an Excel version of their own data with the macros embedded in the downloaded spreadsheet. This enhanced process will provide data transparency and allow facility managers to change assumptions if needed.

The selected algorithms are based on field test estimates built from assumptions used by PNNL during their water balance assessments of four of the eight NZW pilots in 2012 and 2013. The PNNL assumptions were used because they are based on Army installations. By contrast, the more accepted AWWA assumptions, used by PNNL's subcontractor, are based on civilian municipalities. In addition, PNNL viewed the conservative assumptions based on the *Water Use and Conservation Handbook* (Vickers 2001) as being more accurate when finalizing the water balance calculations (McMordie-Stoughton, interviewed in January 2013). These assumptions may change as the results of the algorithms are compared with demand data taken from metered buildings at military installations.

### 5.1 Domestic

Algorithms for domestic fixtures are complex; they rely on estimated daily occupancy, time of day use, type of building, and demographics. It takes a great deal of coding to combining these factors with measured flow rate, expected duration of use, and number of fixtures to produce useful demand estimates that make sense. At this point in the algorithm assessments, building level demand totals must be interpreted as standalone information; refinements will be made in the future.

Building level data required for the algorithms to work need:

- estimated daily occupancy
- time of day occupancy:
  - o daytime (assuming a 9-hr work day)
  - o nighttime (typically barrack or lodging)
  - o 24hrs/day (i.e., hospital)
- occupant demographics (i.e., the percentage of daily users who are women or men).

Total daily occupancy is multiplied by the percentage of men or women to estimate the number of men and women in the building daily. The number of days a building is occupied is estimated using the inputs and assumptions for daily use to calculate yearly demand (Table 6). Tables 7 and 8 summarize the different use assumptions for women and men. The combination of these assumptions, paired with sample fixture flow rates and flush durations should give a conservative estimate of daily and annual building water demand if the occupancy is constant.

Table 7 lists the assumptions for daytime use (Vickers 2001). If the occupancy changes drastically, estimates should be scaled up or down accordingly. Nighttime domestic fixture use differs from daytime use because, at night, occupants access a private bathroom, whereas in the daytime, they commonly use a public restroom. Table 8 lists the assumptions for nighttime fixture use (Vickers 2001).

**Table 6. Number of days to estimate yearly demand.**

| Estimate Days of Occupancy         | Days |
|------------------------------------|------|
| Regular, every day of the week     | 365  |
| Weekdays only                      | 260  |
| Weekend only                       | 104  |
| Weekdays with less on the weekends | 300  |
| Weekends with less on the weekdays | 130  |

**Table 7. Daytime use assumptions.**

| Daytime Military (All)/Civilian - 9 hr Work Day Fixture Use | Assumption for Daytime Use |
|-------------------------------------------------------------|----------------------------|
| Toilet use per day - male                                   | 1                          |
| Toilet use per day - female                                 | 3                          |
| Restroom faucet runtime per use                             | 0.25 minute                |
| Urinal use per day - male                                   | 2                          |
| Showerhead run time min per person                          | 5.3 minutes*               |
| *Based on per capita estimates (Vickers 2001)               |                            |

Table 8. Morning/evening use assumptions.

| Morning/Evening Military On-Post (Barracks and Lodging) | Assumption |
|---------------------------------------------------------|------------|
| Toilet use per day -male (no urinal)                    | 3          |
| Toilet use per day -male (with urinal)                  | 1          |
| Urinal use per day –male (with urinal)                  | 2          |
| Toilet use per day- female                              | 3          |
| Bathroom faucet min per day                             | 2          |
| Kitchen faucet min per day (in room)                    | 5          |
| Showerhead run time per person                          | 8*         |
| *Based on average shower time per person (Vickers 2001) |            |

### 5.1.1 Toilets and urinals

Most of the public toilets observed on Army installations are flushometer type toilets. Water flow in flushometer toilets can be estimated by timing the duration of the flush to verify whether the flush capacity is as rated. Five seconds is typical for 1.6 gallon per flush rated flushometer. Tank toilets are harder to estimate and require additional specialized equipment to measure the flow within the toilet itself. For the sake of expediency during audits, tank toilets are not measured; their rated capacity is used for inputs unless there is a noticeable leak or running water during the tests. The number of toilet uses by men also depends on the availability of urinals (Table 8).

The formulas for flushometers toilets are:

$$\text{Daily use (gal/ay)} = (\text{measured flushometer or rated tank toilets flush rate (gal/flush)} \\ * (\text{toilet use per day (men and women)})$$

$$\text{Yearly demand (gal/yr)} = \{(\text{male daily use [gal/day]}) + (\text{female daily use (gal/day)})\} \\ * \text{days per year}$$

The formulas for urinals are:

$$\text{Daily use} = (\text{measured flushometer}) * (\text{urinal use per day men})$$

$$\text{Yearly demand (gal/yr)} = (\text{male daily use [gal/day]}) * (\text{operating days/yr})$$

### 5.1.2 Faucets and showerheads

Faucets flow rates are measured through calibrated bags that measure the flow rate of the faucet. Both hot and cold temperatures are recorded to estimate energy required to heat ambient water. Temperatures above 120 °F are noted for future reference so facility managers know to check the building's water heater temperature.

The formulas for faucets are:

$$\text{Daily use (gal/day)} = (\text{measured flow rate (gpm)} * (\text{No. of occupants}) * (\text{three uses each at 0.25 min/use}))$$

$$\text{Nighttime use (gal/night)} = (\text{measured flow rate (gpm)} * (\text{No. of occupants}) * (2 \text{ or } 5 \text{ min/day}))$$

$$\text{Yearly demand (gal/yr)} = (\text{daily use/nighttime or combined}) * (\text{occupied days/yr})$$

The formulas for showerheads are:

$$\text{Daily use (gal/day)} = (\text{measured flow rate (gpm)} * (\text{No. of occupants}) * (\text{No. of occupants using shower}) (5.3 \text{ min/use}))$$

$$\text{Nighttime use (gal/night)} = (\text{measured flow rate (gpm)} * (\text{No. of occupants}) * (8 \text{ min/day}))$$

$$\text{Yearly demand (gal/yr)} = (\text{daily use/nighttime or combined}) * (\text{operating days/yr})$$

## 5.2 Commercial/industrial equipment

The formula for clothes washers is:

$$\text{Yearly demand (cu ft/yr)} = (\text{water factor [cu ft]} * (\text{estimate loads per person per week}) * (\text{No. of users/wk}) * (\text{operating days/yr}) / 7)$$

The formula for residential dishwashers is:

$$\text{Yearly demand (gal/yr)} = (\text{gal/cycle}) * (\text{estimated weekly use}) * (52)$$

The formula for drinking fountains is:

$$\text{Yearly demand (gal/yr)} = (\text{measured flow rate}) * (\text{estimate daily use [min]}) * (\text{operating days/yr})$$

The formula for wash fountains is:

$$\text{Yearly demand (gal/yr)} = (\text{measured flow rate}) * (\text{estimate daily use [min]}) * (\text{operating days/yr})$$

The formula for commercial dishwashers is:

$$\text{Yearly demand (gal/yr)} = (\text{gal/rack}) * (\text{No. of racks/hr}) * (\text{duration of use [hr/day]}) * (\text{operating days/yr})$$

The formula for food steamers is:

$$\text{Yearly demand (gal/yr)} = (\text{water consumption [gal/hr]}) * (\text{duration of use [hr/day]}) * (\text{operating days/yr})$$

The formula for a pre-rinse spray valve is:

$$\text{Yearly demand (gal/yr)} = (\text{measured gpm}) * (\text{estimate daily use [min/day]}) * (\text{operating days/yr})$$

The formula for an ice machine is:

$$\text{Yearly demand (gal/yr)} = ([\text{estimated daily ice usage}] / 8.3 \text{ lb/gal}) * (\text{operating days/yr})$$

The formula for a food disposal is:

$$\text{Yearly demand} = (\text{min rated flow required [gpm]}) * (\text{estimated daily hours of use}) * (\text{operating days/yr})$$

### 5.3 Lab-medical equipment

Note that, for lab-medical equipment, units and cycle are specific to the equipment being audited.

The formula for lab-medical equipment is:

$$\text{Yearly demand} = (\text{use cycle:units}) * (\text{estimated daily usage/operation cycle}) \\ * (\text{operating days/yr})$$

### 5.4 Cooling towers

The formula for cooling towers is:

$$\text{Yearly demand} = (\text{makeup water per hour}) * (\text{annual hours operating})$$

Chiller tonnage will determine rate of makeup water consumption. The formulas may be used to calculate the evaporation rate and flow rate based off tonnage and heat rejection. To calculate the makeup water flow rate, determine the evaporation rate using one of the following:

$$\text{Evaporation rate (gpm)} = \sim 2 \text{ gpm per 1 million Btu/hr of heat rejection}$$

$$\text{Evaporation rate (gpm)} = \sim 3 \text{ gpm per 100 tons of refrigeration}$$

$$\text{Evaporation Rate (gpm)} = \text{water flow rate (gpm)} \times \text{range (}^{\circ}\text{F)} \times 0.001$$

Multiply the evaporation rate by the appropriate correction factor in Table 9 to calculate the makeup water flow rate, in gpm and convert to hours.

Table 9. Evaporation rate correction factor.

| Cycles of Concentration                                                                                               | Correction Factor |
|-----------------------------------------------------------------------------------------------------------------------|-------------------|
| 2                                                                                                                     | 2.00              |
| 3                                                                                                                     | 1.50              |
| 4                                                                                                                     | 1.33              |
| 5                                                                                                                     | 1.25              |
| 6                                                                                                                     | 1.20              |
| 7                                                                                                                     | 1.17              |
| 8                                                                                                                     | 1.14              |
| 9                                                                                                                     | 1.13              |
| 10                                                                                                                    | 1.11              |
| Source: <a href="http://www.gorhamschaffler.com/tower_makeup.htm">http://www.gorhamschaffler.com/tower_makeup.htm</a> |                   |

## 5.5 Steam boilers

If the makeup water for the boiler plant is metered, then:

Yearly Demand = annual total of makeup usage.

If the plant makeup water is not metered, it can be estimated from the amount of boiler blow-down plus the amount of steam used or lost in the steam distribution system. It is assumed that the system losses in the distribution system (outside the plant) will be counted as water use during building surveys. If the annual plant steam output is metered and boiler feedwater is metered, then:

Yearly Demand = annual total of blow-down  
= annual total of feedwater - annual steam output.

If the annual plant steam output is metered, but boiler feedwater is not metered, determine if the concentration of chlorides or dissolved solids in the feedwater and blow-down are measured. If so, then:

Yearly Demand = annual total of blow-down  
= (annual steam output)\*(average concentration in feedwater)/  
([average concentration in blow-down] - [average concentration in feedwater]).

If annual total of blow-down cannot be determined by the above methods and an estimate is available, then:

Yearly Demand = estimated annual total blow-down.

If none of the above is available, assume the makeup water use is 12% of the annual plant steam output:

Yearly Demand = 0.12\*(annual steam output).

If steam output is not metered, but boiler fuel use is metered, assume annual plant steam output is 80% of total annual boiler fuel use. Then:

Yearly Demand = 0.12\*0.80\*(total annual boiler fuel use)\*(1 lb/1,000 Btu).

If neither steam output nor fuel use is metered, assume that:

Annual plant steam output = 35% of total output ratings for operated boilers running for a 7 month heating season (5,110 hrs).

Then:

Yearly Demand = 0.12\*0.35\*(total hourly steam output rating of operated boilers)\*(5,110 hrs).

## 5.6 Motor pool vehicle wash

The formula for motor pool vehicle washes is:

Yearly demand = (rated flow of hand held nozzle [gpm]) \* (No. of nozzles)  
\* (wash time per vehicle [min]) \* (total No. of vehicles) \* (2 washes/yr/vehicle)

## 6 Field Tests

Initial plans were to field test the MICA:WET application at two installations, but when three additional locations became available, field testing was expanded to include five sites: (1) Fort Hood, TX, (2) Fort Campbell, KY, (3 & 4) two laboratory sites at WES, in Vicksburg, MS, and (5) Fort Leonard Wood, MO.

The first two field tests were organized in tandem with the BUILDER program adoption expansion schedule within the Army. BUILDER's first Army pilot sites included Fort Hood and Fort Campbell. The MICA:WET project benefited greatly from working with BUILDER because the established audit dates synchronized well with MICA:WET's project timeline; both projects had coordinated access to installation buildings. The BUILDER field audit teams were very amenable to allowing additional CERL personnel to be present to test the MICA:WET app.

Visits were made to Fort Hood in December 2012 and January 2013. The field test at Fort Campbell occurred in late January 2013 with assistance from a water audit team from PNNL. In March 2013, the MICA:WET team accompanied a Level 1 energy-water audit team who conducted a field survey of approximately 41 buildings at WES. The final field test was performed at Fort Leonard Wood, MO. This last site visit afforded the additional opportunity to field test the application with multiple auditors to help determine if the collected data could be standardized among multiple, novice users, and whether the interface and data collections steps were readily understandable and user friendly.

Field tests of MICA:WET were essential in refining the app's usability, accuracy, and applicability. Much of the field tests involved identifying how well the initial data schema worked. In addition, the first field test provided useful exposure to how an experienced auditing team worked in the field. The last field test helped improve some of the final details and wording of inputs so auditors can interpret the data request correctly.

## 6.1 Fort Hood, TX

Fort Hood's principal cantonment area is adjacent to the City of Killeen located in Central Texas. Access is via US Highway 190, a four lane controlled access road that flows directly into Interstate-35. The installation is located 60 miles Northeast of Austin, TX.

Fort Hood serves as a mobilization station for Army Reserve and National Guard units and as a strategic power projection platform. The installation serves a wide variety of tenant organizations and is the only post in the United States capable of supporting two full armored divisions. The installation, which covers an area of 340 square miles, is the second largest active duty Army post, with some 52,000 uniformed personnel. Total population consists of 218,003 active duty Service members, family members, and civilians, with a support population of 246,718, i.e., retirees, survivors, and family members (Fort Hood Public Affairs Office [PAO] 2009).

### 6.1.1 1<sup>st</sup> Visit: BUILDER field coordination

The first visit to Fort Hood in December 2013 was an observation trip to determine how to best take advantage of the access available through the ongoing coordination between BUILDER field assessment teams. During the visit no field data were collected, but notes on Cardno Techs methods, timing, and data transfer efforts provided valuable insight on how to minimize future interference with their efforts to capture data. The Cardno Tech teams typically consisted of up to five personnel, each member being a subject matter expert dedicated to one building system type. The teams were comprised of experienced field engineers who moved quickly through a building and visually assessed and captured details via written notes, photos, or tablet computers.

Each team member had a Windows®-based tablet computer that required a stylus to interact with the screens, unlike typical touch screens such as iPads or Android tablets. These tablets worked like personal computers where the stylus acted more like a mouse. The teams mentioned that the styli were difficult to handle in the field as they required fine and precise interactions. Most members preferred to take hand-written notes while walking through the building and then to transfer the notes to the tablets later while sitting at a table, using a keyboard and mouse (Cardno Tech 2013). The additional time to transfer their data following an audit took from 30 to 60 minutes per building depending on the complexity of the building.

### **6.1.2 2<sup>nd</sup> Visit: First tablet field test next to BUILDER teams**

The second visit to Fort Hood in January 2013 was the first field test of the MICA:WET app. The goal was to test the tablets, the application, its interface, and its ability to upload data remotely. The field test was conducted by one person to determine how quickly water audit data could be collected by one person and if that one person could keep up with the Cardno Tech team, which averaged about 2 minutes per assessed barrack room.

At the beginning of the auditing process, it took more time to prepare or “build” rooms within the application (see Chapter 6 for instructions), lengthening the overall time to capture room data. However, repetition in bathroom designs and equipment allowed for the creation and use of templates; this sped the preparation, after which fixture measurements, photos, and notes became the primary effort. The templates sped up the time for auditing a building so much that data collection, notes, and photos could be completed as the Cardno Tech team was beginning the transfer efforts to their tablets. If Cardno Tech would create a BUILDER application tailored to their data needs, the time saved would be substantial.

## **6.2 Fort Campbell, KY**

Fort Campbell is situated in western Kentucky and Tennessee, between Clarksville, TN and Hopkinsville, KY. Located off Interstate-24, approximately 55 miles northwest of Nashville TN. Fort Campbell, is home to the only air assault division in the world, the 101st Airborne Division (Air Assault). Fort Campbell is the third largest military population in the Army and the seventh largest in the DoD. The installation has a total military population of 30,656, of which 8,040 are civilian employees, 51,740 are family members, and 112,454 are supported population (retirees and family members). The installation covers an area of 105,000 acres and contains over 4,000 homes that provide housing for officers, enlisted soldiers, and their families. Located on the post are five elementary schools, two middle schools and one high school, a major hospital, child care facilities, many chapels, banks, restaurants, post exchanges, service stations, campgrounds, five swimming pools, and other facilities (Fort Campbell 2012).

### **6.2.1 Field Test with PNNL water audit team**

The second table tablet field test was conducted at Fort Campbell in collaboration with Cardno Tech and Fort Campbell DPW. To assist with and

provide feedback on the application interface design and data collection protocol, the MICA:WET team was accompanied by a two-person team from PNNL (Kate McMordie-Stoughton and Brian Boyd), both of whom have extensive experience in the domestic and industrial side of water use. As water auditors, their feedback on how the data schema and the user interface could be improved was essential in helping to design the formulas required to estimate building level demand.

### **6.2.2 Field test results**

An additional goal during PNNL's participation in the field test was to determine the level of detail of data classification that was required to merge data from multiple auditors working at the same time in the same room, without duplicating data, or overwriting initial data with subsequent data.

Two tablets were tested side by side with separate logins to collect separate fixture data from adjacent fixtures in one room. The data were then uploaded separately to determine if the separate data combined to complete an entire audited room. On the first day, tests showed the last upload overwrote the previous upload or created a double set of data. These double errors were actually a result of the field auditors providing different designations to floors and rooms in a way that created a duplicate and parallel set of data for the same room. After further coordination with the auditors and some code changes, the second day tests provided accurate combined data within the same room. As a result of this test, the data schema was changed to encourage floor and room designation notifications each time an auditor refreshes those level inputs.

During this field test, it was also noted that a team of two (one dedicated data input person and the other dedicated to handling, testing, and measuring equipment) provided more accurate data in less time than two persons independently performing all the functions.

## **6.3 Waterways Experiment Station, Vicksburg MS**

WES is the largest civil engineering and environmental quality R&D complex in the United States. Its R&D studies support the civil and military missions of the Army Corps of Engineers. The facility was established in response to the nationally-destructive Mississippi River Flood of 1927; WES continues to study river, harbor, and flood-control projects.

A separate energy and water survey that was relevant to the MICA:WET efforts was conducted at WES to identify energy and water inefficiencies and waste, and to propose energy and water-related projects with applicable funding and execution methods that could enable the installation to better meet the energy and water reduction requirements mandated by EISA 2007, EO 13123, and by the Energy Policy Act of 2005, and that could satisfy the energy and water survey requirements of EISA 2007, Section 432.

The survey was conducted by an energy and water team, composed of subject matter experts from ERDC-CERL and the US Army Engineering and Support Center, Huntsville, AL (HNC).

The scope of the energy portion of the survey included a Level I energy optimization assessment study. Thirty-six of the 41 buildings with large energy and water demands were visited. The study identified economically viable water conservation measures (WCMs) that, if implemented, would reduce WES's annual water use by up to 1 kgal/yr. A separate report will summarize these WCMs, categorized into eight "packages," and recommendations for implementation strategies.

### **6.3.1 Level 1 audit at WES**

#### *6.3.1.1 Summary of Level 1 audit*

A Level 1 water audit using the MICA:WET application was done on 36 buildings throughout the WES facility. The audit included visual qualitative and quantitative assessments on a variety of buildings. The major building types assessed were administrative, laboratory, and industrial scale modeling research. Outdoor irrigation was noted and photographed at four buildings. Each audited building was classified into determinant end-uses in terms of water quality, clarity, and quantity to determine where efficiency upgrades would be most beneficial. In many of the laboratory research locations, the quality and clarity of water was essential in conducting the experiments; therefore, in these uses, efficiency would not improve the research, but might actually hinder it. In end-uses where quantity was desired, such as in the 1:50 scale models of the Columbia River, quantity was required to simulate actual sites. In some of these end-uses, some efficiency potential existed with quantity and clarity.

The infrastructure throughout WES, including significant leaks, was assessed. Before arrival, overall monthly consumption patterns, meter locations, and billing trends were assessed before arrival. Face-to-face interviews were conducted with laboratory and campus DPW personnel regarding cooling towers, infrastructure, irrigation, and significant users.

#### *6.3.1.2 Results of Level 1 audit*

The unique nature of WES's mission provided an interesting challenge to the data schema designed for military installations. Much of the industrial and laboratory level water uses at WES are within closed loop hydrologic water models that can span hundreds of yards. In some cases, the facility changes its experiments regularly over a decade, while in others, it may keep river models staged for occasional use. These types of use are unique to WES; consequently, it was difficult to classify many of the industrial sites with MICA:WET. However, the photo capability within the app was useful as a photo file management tool that provided easy reference to recordable (photographic) information required for the report.

Despite this utility, an ongoing programming "bug" causes photos to become associated with the wrong building, floor, and room after an initial upload while data are still being collected. This photo association error shows up strictly on the app and is being researched. Despite this jumbling of photos on the app, the downloaded photos are correctly associated when accessed through ITL's web links.

## **6.4 Fort Leonard Wood, MO**

Located in the heart of Ozark Mountains, Fort Leonard Wood is comprised of 63,000 acres of land, most of which is used for training. The Fort is located in Pulaski County, MO, is 2 miles south of Interstate 44, which provides access to St. Louis, MO to the east. Fort Leonard Wood hosts the premier Army Center of Excellence which trains 80,000-90,000 military and civilians each year (MyBaseGuide.com 2012).

### **6.4.1 First audit at large Army Installation**

#### *6.4.1.1 Summary of first audit at large Army Installation*

Between 24 and 28 June 2013, three teams of water auditors surveyed 40 buildings chosen by Fort Leonard Wood Department of Public Works using the MICA:WET tool. The types of buildings surveyed included dining,

barracks, administrative, recreational, and small industrial facilities. Five flow recorders were installed at metered buildings to capture usage trends. Level 1 audits were performed on barracks. Level 2 audits were performed on the dining facilities and administrative buildings that varied from floor to floor.

The survey teams varied in age and experience with using a tablet. Three training sessions were conducted to familiarize the teams with the MICA:WET application while introducing water auditing concepts, methods, and strategies. The teams were given some background information on commercial kitchen appliances, medical steam sterilizers, and toilet types to ensure they were able to visually identify equipment before auditing and classifying them (Appendix A). During the audit, a quality assurance review of collected data was performed the first night to ensure they the teams collected and recorded data in a standard practice. When dissimilarities were found, ITL personnel were requested to improve the interface to mitigate misinterpretation. Appendix C to this report contains the complete agenda and team summaries.

#### *6.4.1.2 Results of first audit at large Army Installation*

At this writing, data have been downloaded, including photos from ITL's web links, but the analysis is not yet completed. Since the teams worked separately in separate buildings, issues related to data merging were avoided and could not be evaluated. The main test of this audit and data analysis was to determine if trained auditors can capture high quality data to work with the existing algorithms. During the audit, efforts were made to ensure that all separate tablet entries were standardized and any questions on the schema were answered to increase data quality. At the time of this publication, the algorithms are being revised and tested.

## **7 Auditing with the MICA:WET tool**

### **7.1 Equipment list**

The following is a recommended, but not a finite, list of equipment that should be used in helping conduct a water audit at military installations using the MICA:WET tool:

- mobile tablet capable of running the Android operating system
- infrared (IR) gun
- mirror
- multi-tool
- hard-hat
- high-visibility vests
- stop-watch
- flow rate bags
- water pressure gauge
- hand sanitizer.

### **7.2 Application training**

MICA:WET auditor training (three, 1 hour sessions) for six personnel was performed at CERL for the Fort Leonard Wood water audit. Trainees were directed through the registration process and provided supplemental equipment material and photos for familiarization to review before the audit. (See Appendix A for supplemental sources and references.) Auditors were also provided tablets for orientation with the application. They were also given a draft manual to reference in case they had specific functions to perform and needed guidance. The intent of the training was not to make experts of the auditors, but to familiarize them with the equipment so they would rely on MICA:WET to guide their data collection and to answer their questions. If algorithmic information was required, the app would place a notification on the screen to remind auditors to enter the needed data. Feedback from the trainees was positive; they expressed the opinion that much of the interface was intuitive once they understood the data that needed to be collected.

## 7.3 Directions for application use

The MICA:WET app is coded and will have screen shots formatted specifically for the Samsung Galaxy 10.1 tablet, but that can be coded for compatibility with other types of tablets. Thus, the basic desktop views will likely be different if a different tablet brand or model is used. Some of the specifics, such as the set of icons at the bottom left of the desktop screen, should not be assumed to be present on other models. The screen shots specific to the application should now be accurate, but may differ slightly over the years as the MICA:WET software is updated.

The MICA:WET application is meant to guide installation managers in collecting data necessary for estimating building consumption and to create an up-to-date inventory of their water equipment. Users of this application are assumed to have a basic working knowledge of their facilities. Consumption data for some end-use fixtures, such as large appliances, may be difficult to assess in the field. In such instances it is recommended to take photos of the equipment including its nameplate information so its data may be determined later through the Internet or by some other means.

### 7.3.1 Getting the project started

Before deciding to use MICA:WET, it is important to coordinate the scope of the water audit project with support personnel at ERDC-ITL. ITL personnel manage database setup, and ITL servers house the data and web interface for access by users. It is recommended that installation managers compile a real property list using an Excel<sup>®</sup>-compatible spreadsheet of buildings to be audited, and then send it to ITL to be used in the project setup. ITL support personnel can upload the list so that it is available to the auditors when they refresh their tablets.

To access the collected field data, installation managers must also coordinate with ITL to obtain an account for the NZI Tool web interface. This is separate from the MICA:WET application login and can be done before or after registering for MICA:WET app access.

### 7.3.2 Screen navigation

Although the MICA:AM software can be downloaded on other mobile devices, the Samsung Galaxy Note 10.1 tablet will be used for illustrating a water audit using MICA:WET. Navigational tools specific for this device

are located at the bottom left of the screen. To select an application, touch an icon located on the home screen (Figure 2). The best tool for using the tablet is a finger.

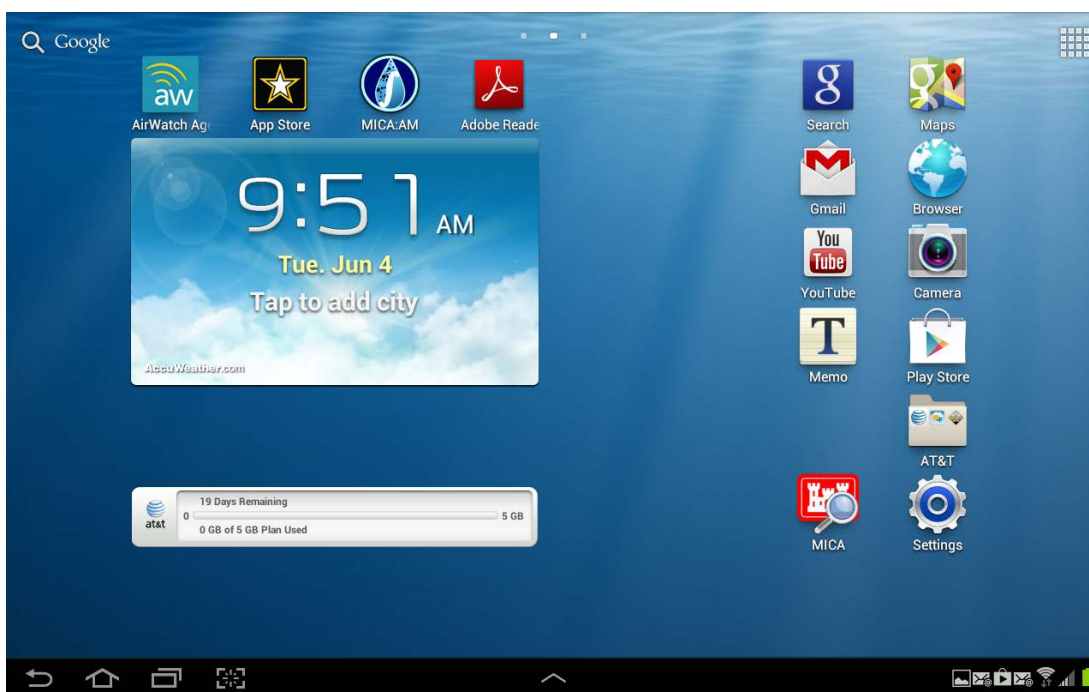


Figure 2. Tablet Home screen.

### 7.3.3 Connecting to WI-FI

While some tablets may be set up to use cellular connection, the Samsung Galaxy 10.1 tablet uses Wi-Fi to connect remotely to ITL servers. Once it is turned on, the tablet will automatically search and try to connect to available Wi-Fi services. If the Wi-Fi service requires a login, the tablet may say it is connected to the Wi-Fi, but without the login to the local service, e.g., hotel, coffee shop, etc., it will not be actively connected. To check this, the user should open the web browser icon on the 'desktop' screen. If the user can navigate the Internet freely, then the tablet is connected. If a login page comes up, the user must login using the browser before being actively connected to the Wi-Fi service. After connection, the user should be able to open MICA:WET and connect to the ITL servers remotely.

*Note that the tablets do not need to be connected to WI-FI or cellular systems during field audits to collect and store data. They need connections only for uploads and refreshes.*

Wi-Fi Indicators are:

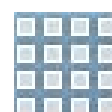
1. **Wi-Fi Active:** Wi-Fi is connected, active, and communicating with a Wireless Access Point (WAP).
2. **Wi-Fi Action Needed:** Action needed to connect to a WAP.



### 7.3.4 Command icons

Command icons are located on the bottom left of the screen. These are basic control keys used for controlling applications and other basic commands.

1. The **Back Button** allows a user to go to the previous page or activity.
2. The **Home Button** is used to jump to the home screen of your mobile device. Using this button will, usually, not shut down any application or game; instead, it will run in the background.
3. The **Recent Apps Button** is used to open a list of thumbnail images of apps you have worked with recently. Touch an App to open it.
4. The **Screen Capture** button takes a screenshot of the screen currently displayed. Screenshots are saved under the following directory: myfiles → sdcard → Pictures → Screenshots.
5. To view the screen shots:
  - a. From a Home screen, touch **Apps button** located at the top-right corner of the screen.
  - b. Select myfiles and then search for the directory noted above.



### 7.3.5 User registration

1. To use the MICA:AM software, users must register with asset management, <https://assetmanagement.usace.army.mil/tools/>. Information must first be registered at the OCA Inland Nav Budget Workbook tab located in the first column (Figure 3). To register the user must have a Common Access Card (CAC).

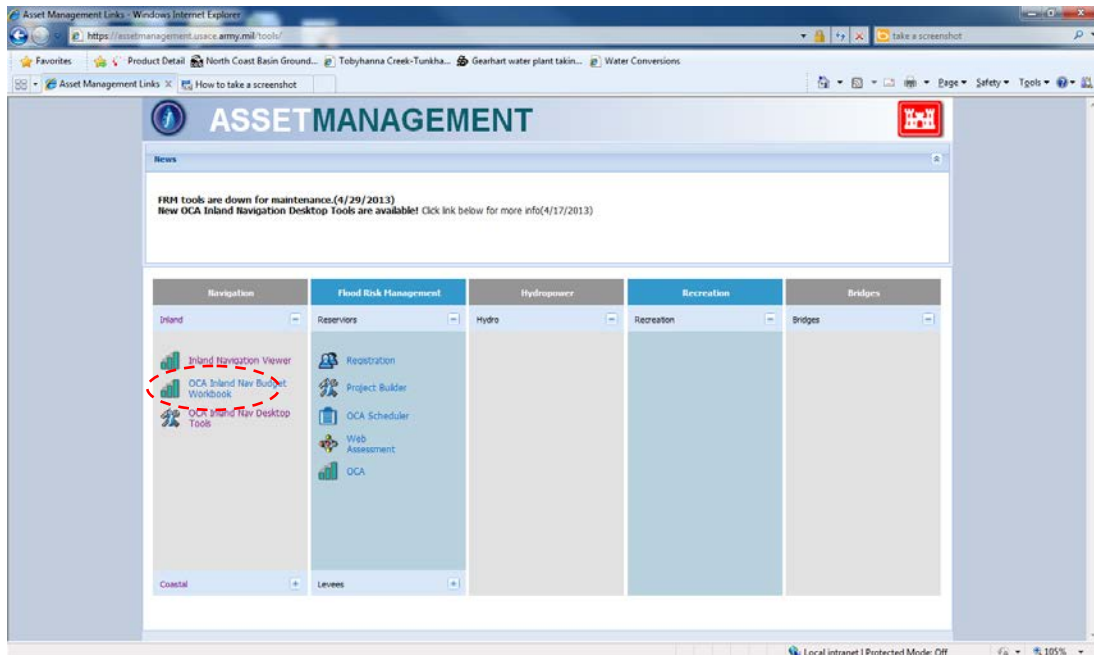


Figure 3. Step 1, Registration.

2. Once this information is recorded, users may proceed to the Registration tab (Figure 4) under the second column. The Registration tab will prompt the user to enter contact information.

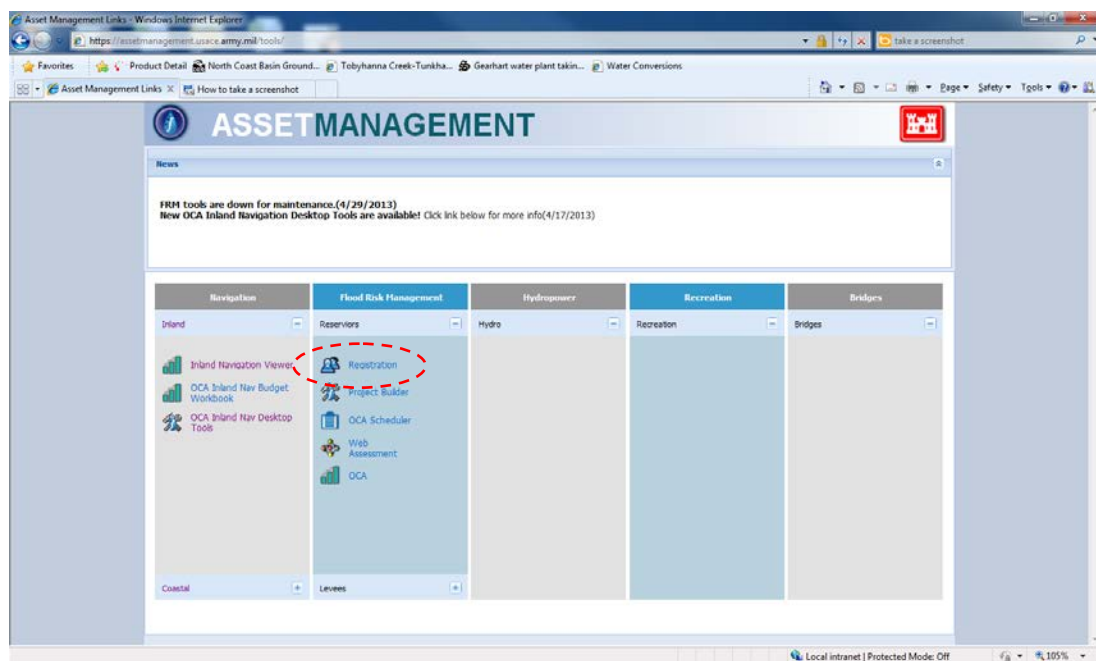


Figure 4. Step 2, Registration.

3. Once the information has been entered, a screen will appear for you to select the tool you wish to use (Figure 5). Each row in the grid represents the different permissions that you can request for that particular tool's grouping. Clicking the green "+" beside a permission will request permission for the use of that tool and auto-generate an email to you stating that you have made that permission request.

The screenshot shows a web browser window with the URL <https://assetmanagement.usace.army.mil/OCA/Registration/User.htm>. The page title is 'User Permissions'. It contains a table with columns: Tool, Permission, Status, and Date Requested. The table lists permissions for various user roles, including FRM OCA, INAV OCA, and NZI Inspection. The status for most permissions is 'Denied', while the NZI Inspection permission is 'Approved'.

| Tool                                 | Permission             | Status   | Date Requested |
|--------------------------------------|------------------------|----------|----------------|
| FRM OCA                              | FRM OCA Coordinator    | Denied   | 06/03/2013     |
| FRM OCA                              | FRM AM PDT             | Denied   | 06/03/2013     |
| FRM OCA                              | FRM RAMS               | Denied   | 06/03/2013     |
| FRM OCA                              | QAQC                   | Denied   | 06/03/2013     |
| FRM OCA                              | Component Manager      | Denied   | 06/03/2013     |
| <b>Tool: INAV OCA (9 Items)</b>      |                        |          |                |
| INAV OCA                             | System Administrator   | Denied   | 06/03/2013     |
| INAV OCA                             | Admin                  | Denied   | 06/03/2013     |
| INAV OCA                             | Inspector              | Denied   | 06/03/2013     |
| INAV OCA                             | National Report Viewer | Denied   | 06/03/2013     |
| INAV OCA                             | Division Report Viewer | Denied   | 06/03/2013     |
| INAV OCA                             | District Report Viewer | Denied   | 06/03/2013     |
| INAV OCA                             | QAQC Viewer            | Denied   | 06/03/2013     |
| INAV OCA                             | Project Staff          | Denied   | 06/03/2013     |
| INAV OCA                             | Budget                 | Denied   | 06/03/2013     |
| <b>Tool: NZI Inspection (1 Item)</b> |                        |          |                |
| NZI Inspection                       | Mobile Team            | Approved | 06/03/2013     |

Figure 5. User permissions.

### 7.3.6 Accessing the application on Android Store

1. To manage ITL Applications, you must first download the AirWatch Agent available in the Google Play Store and Amazon Appstore. Search the app store for AirWatch Mobile Device Management (MDM) Agent (Figure 6) and download it to the mobile device.

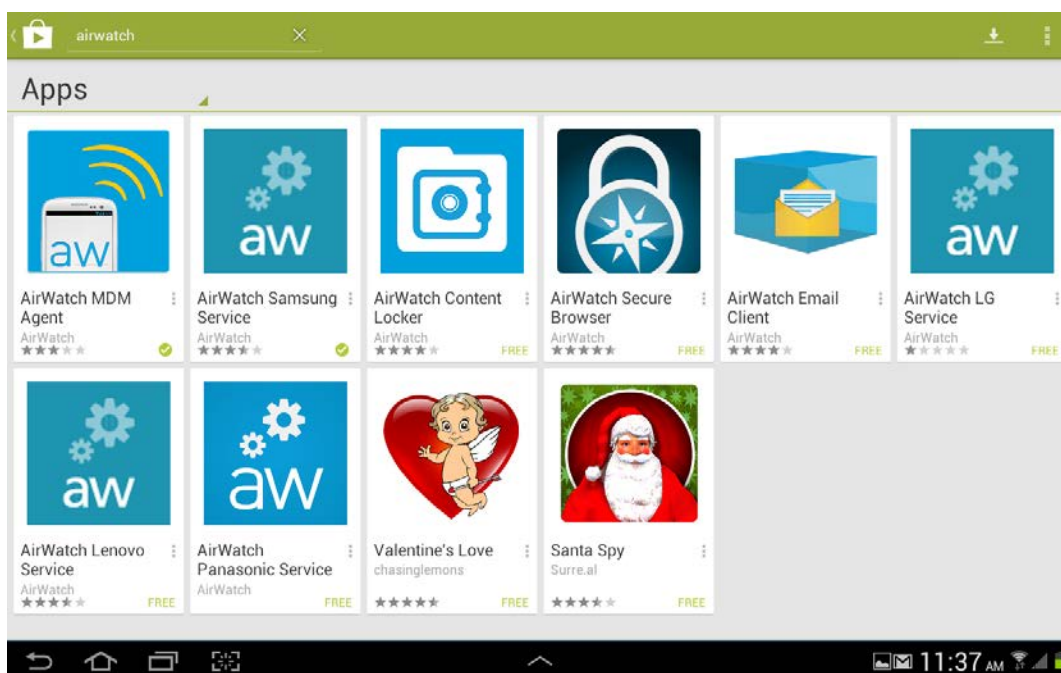


Figure 6. Airwatch App on Google Play.

2. Once the Airwatch App is on the device, search Airwatch Agent (Figure 7) for the **Army App Store** and download this application.

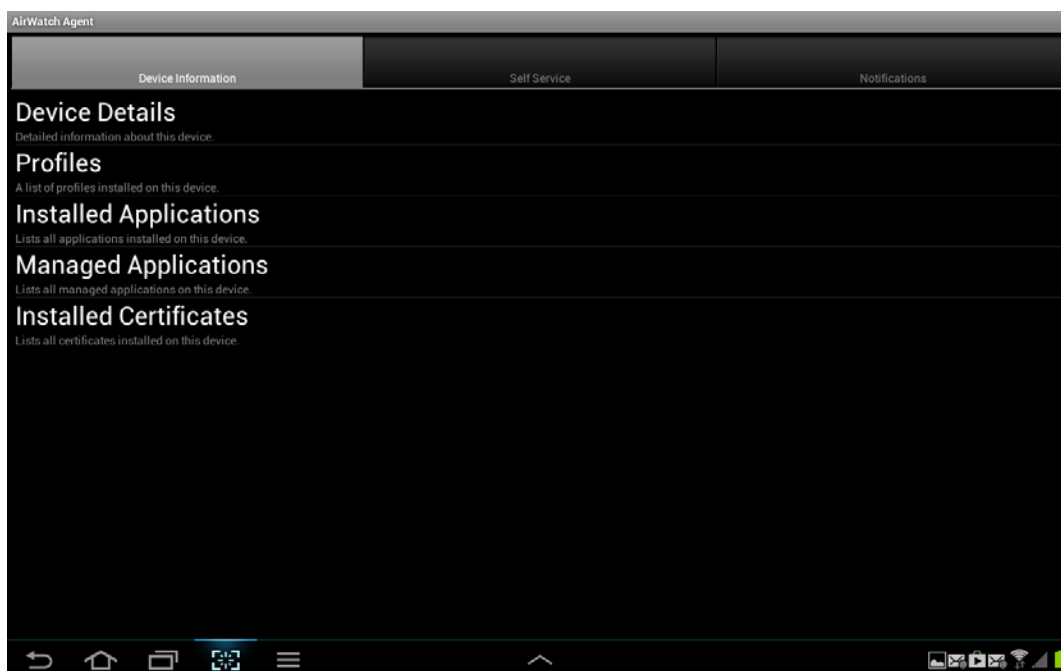


Figure 7. Search for Army App on Airwatch.

3. Search the **Army App Store** for the MICA:AM App and download to the mobile device. During this process, the downloads will request login information that you set up during the first User Registration step.



### 7.3.7 Logging in

1. To log into the software, the user must enter a UPASS user name and CAC personal identification number (PIN) number (Figure 8).



Figure 8. Logging in.

### 7.3.8 Upload, refresh, and updates

1. During the auditing process, data are not automatically uploaded to the server. This requires the user to manually upload the data onto the server by selecting the **Upload** button located at the bottom center of the page.
2. A window will appear asking if you would like to upload changes, media, or both. Selecting **Changes** will only upload data entered into fields; selecting **Media** will upload photos, and audio and video files; selecting **Both** will upload all data to the servers (Figure 9).



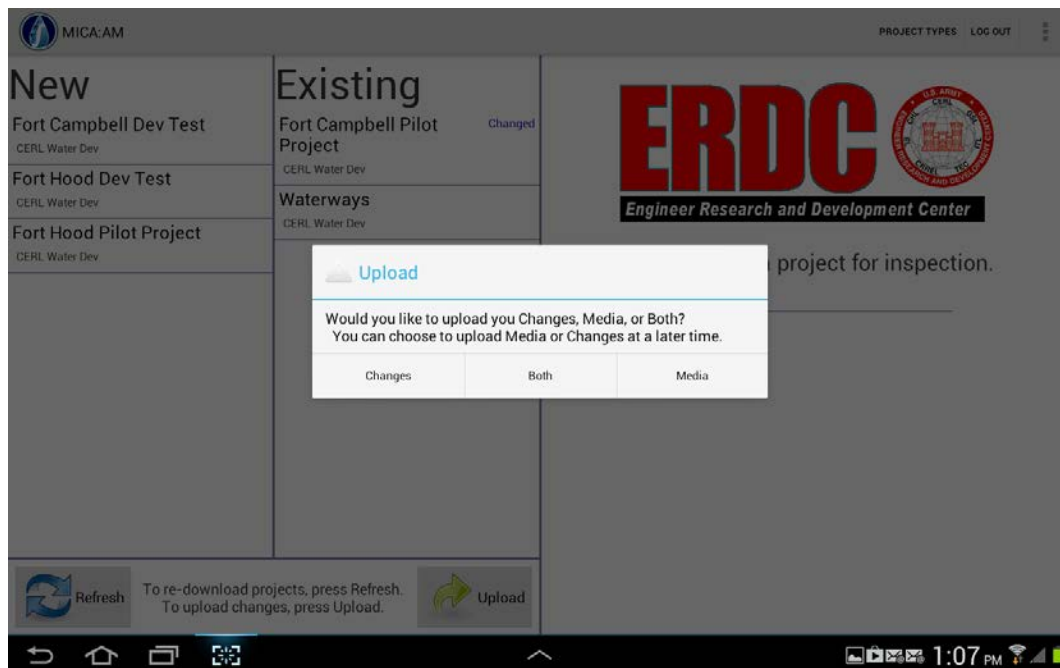


Figure 9. Uploading data.

3. Once the data are uploaded, that project will be 'Locked' until the user uses the 'Refresh' button to synchronize ("synch") the tablet with the server. This process helps with version control between the server and multiple field auditors.
4. To refresh, select the **Refresh** button located on the bottom left of the screen (Figure 10). Refreshing syncs data related to specific projects to the server.



*Note: You may want to refresh before auditing to ensure data are synched with the server and to upload your changes at the end of the day.*

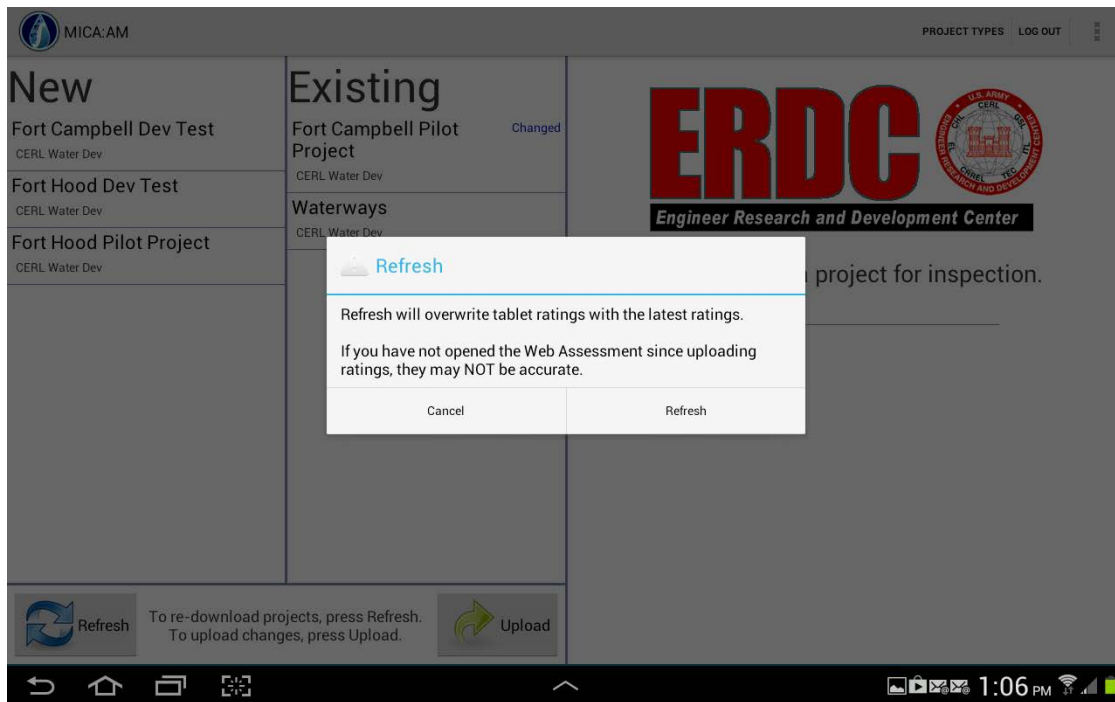


Figure 10. Refreshing data.

5. Occasionally the MICA:AM app will need to be updated. A user will be notified via email or a pop-up notification will occur directly on the app screen. To update the app, select the icon located at the top-right of the screen. If updates are available, the Update App lettering will be black and not grayed out (Figure 11).



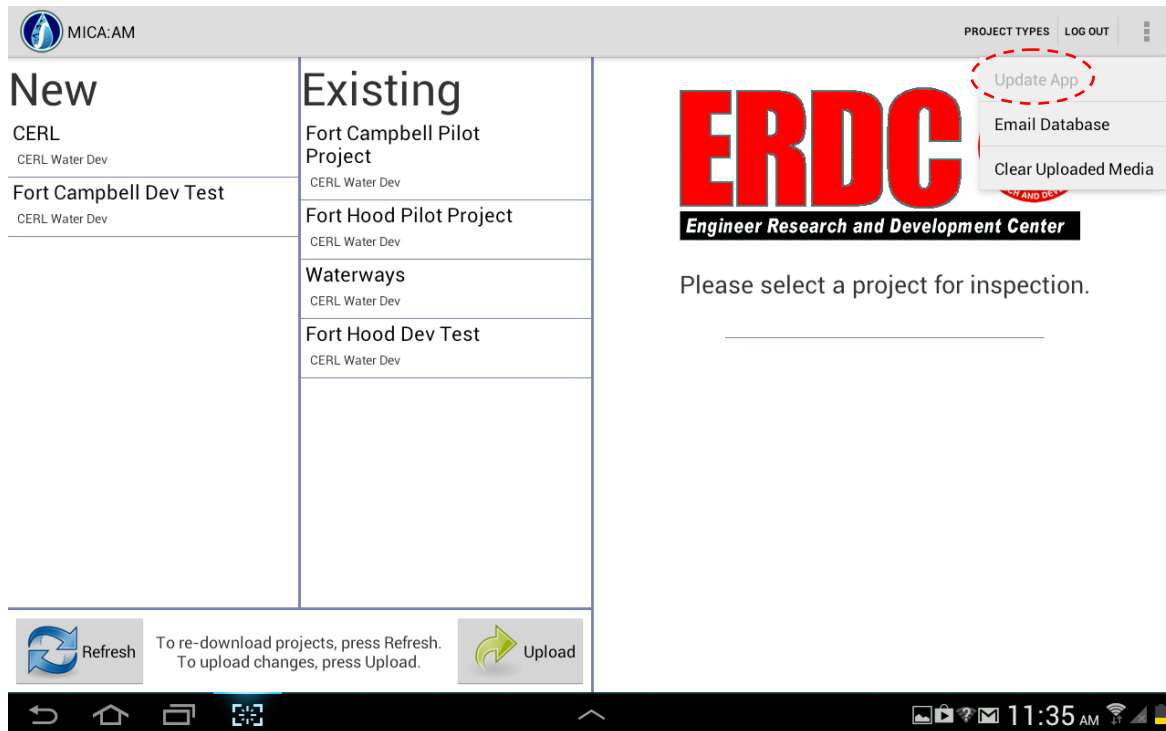


Figure 11. Updating App.

### 7.3.9 Accessing building list

1. To get started on auditing, login into the MICA:AM app. Select the project you wish to start (projects should be uploaded to the server before the audit). If it is a new project, it will appear in the first column under **New**. Existing project are located under the second column (Figure 12).

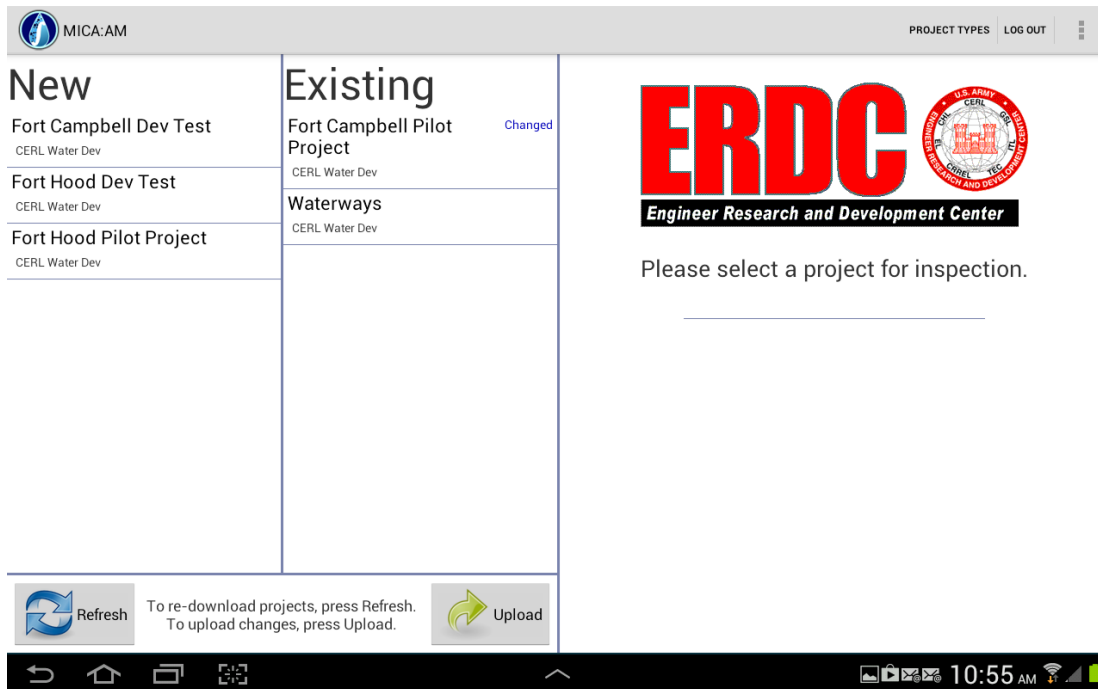


Figure 12. Project List.

2. Once a project has been selected, a list of buildings will appear (Figure 13). This list is generated from the real property database provided by the installation.

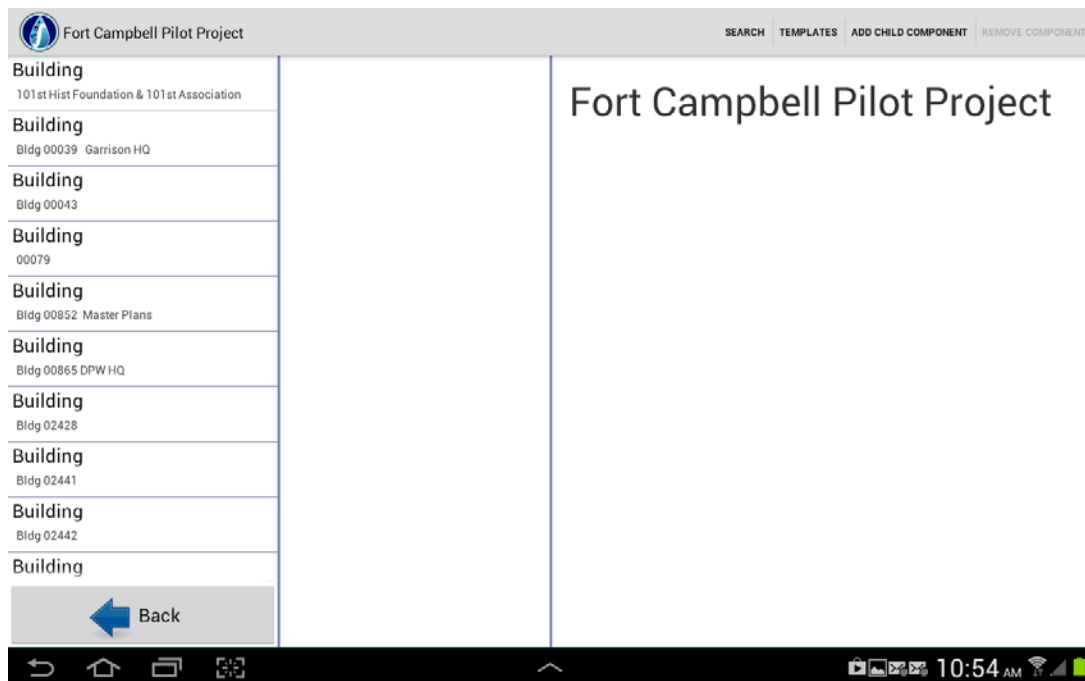


Figure 13. Building list.

3. Unique identifiers such Remote Processor Unit (RPU) IDs and category (CAT) CODES are found in the real property database and can be uploaded before the audit or entered afterwards (Figure 14).

*Note: Notifications for entering building, floor, or room numbers will pop up. This is to ensure data between auditors can be merged within a building/floor/room successfully.*

The screenshot shows a mobile application interface for the Fort Campbell Pilot Project. The top header bar is grey and contains the project name 'Fort Campbell Pilot Project | Building' on the left and navigation links 'SEARCH', 'TEMPLATES', 'ADD CHILD COMPONENT', and 'REMOVE COMPONENT' on the right. Below the header, the left sidebar is titled 'Building' and lists several building entries with their IDs and names. The main content area is titled 'Building' and shows the details for a selected building, '101st Hist Foundation & 101st Association'. It includes three icons for adding media: 'Picture', 'Video', and 'Audio'. Below these are three input fields: 'Number' (with a note 'Used as a unique identifier'), 'RPU ID', and 'Type'. A 'Back' button is located at the bottom left of the sidebar. The bottom of the screen shows a standard Android navigation bar with icons for back, home, recent apps, and a status bar at the very bottom showing the time as 10:56 AM.

Figure 14. Building level fields.

### 7.3.10 Begin auditing a building and adding child components

#### 7.3.10.1 Building level

1. The audit requires the user to enter algorithm data at the building level. Such data include vacancy rates, or typical daily occupant schedules. Data entered into building level fields are specific to the type of building. For instance, if a building is a dining facility, the number of meals should be entered. If barracks or other sleeping quarters, number of beds, demographic percentages. Some fields require the user to enter the data manually or to select from a menu list. For example, the type of building can be selected from a set of typical buildings (Figure 15).

Fort Campbell Pilot Project | Building

SEARCH TEMPLATES ADD CHILD COMPONENT REMOVE COMPONENT

**Building**  
Bldg 00039 Garrison HQ

**Building**  
Bldg 00043

**Building**  
00079

**Building**  
Bldg 00852 Master Plans

**Building**  
Bldg 00865 DPW HQ

**Building**  
Bldg 02428

**Building**  
Bldg 02441

**Building**  
Bldg 02442

**Building**  
Bldg 02525

**Building**

Back

Number  
Used as a unique identifier.

RPU ID

Type

Building has water meter  
If yes, take photo.

CatCode

LEED Certified

Administrative  
Barrack  
BX shopping center  
Car Wash  
Central Heating/Cooling  
Central Plant

11:19 AM

Figure 15. Selecting Type of Buildings level fields.

- Additional data can be included at the building level (Figure 16). First select the building to add a level, then press the **Add Child Component** icon located at the top-right of the screen. Selecting this icon allows the user to add alternative water options, floors, or irrigation. If templates have been created, they can be added at this time.

ADD CHILD COMPONENT

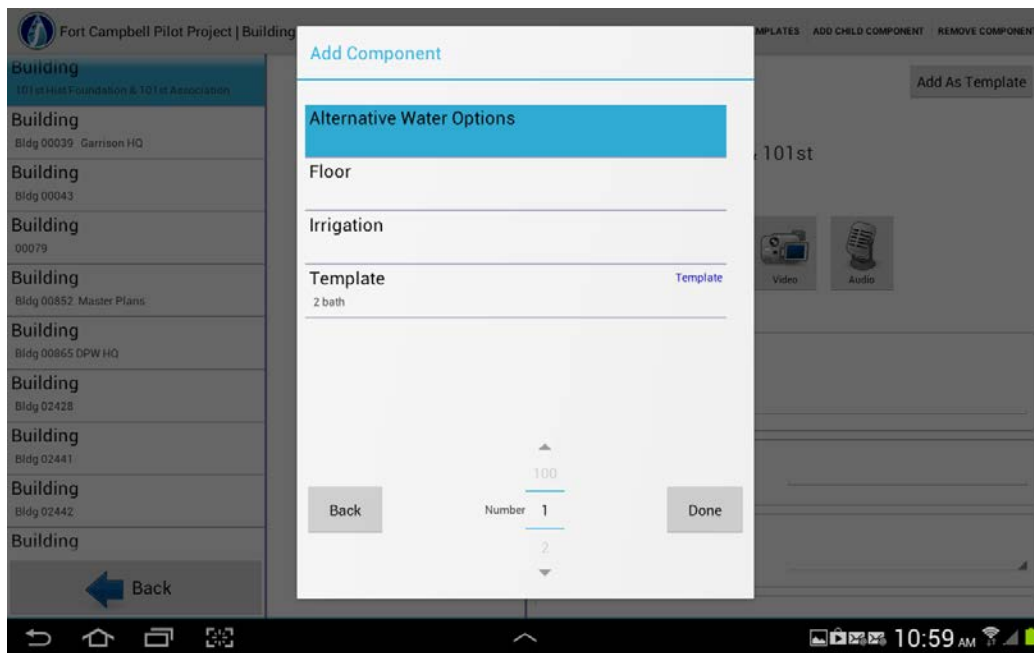


Figure 16. Adding child component.

#### 7.3.10.2 Floor level

1. To add a floor to the building level, select the **Add Child Component** icon and add a floor (Figure 17). The user can select a single floor or add up to 100 floors. In the example, three floors are selected.

ADD CHILD COMPONENT

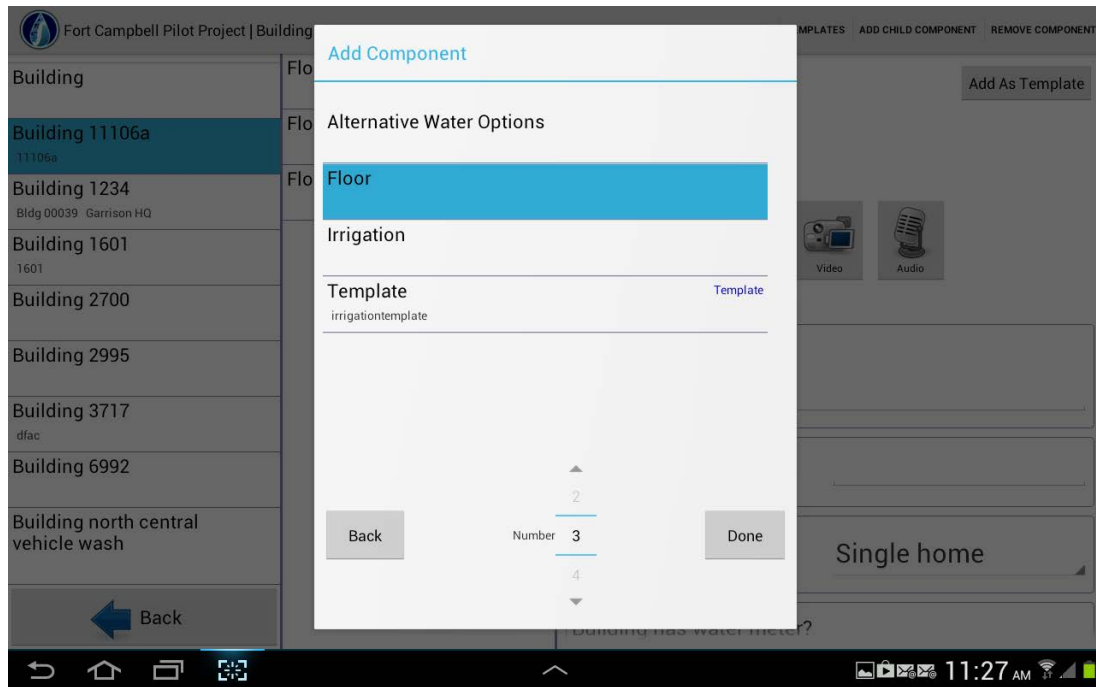


Figure 17. Adding a floor,

2. The floors are added to the second column of the page (Figure 18).

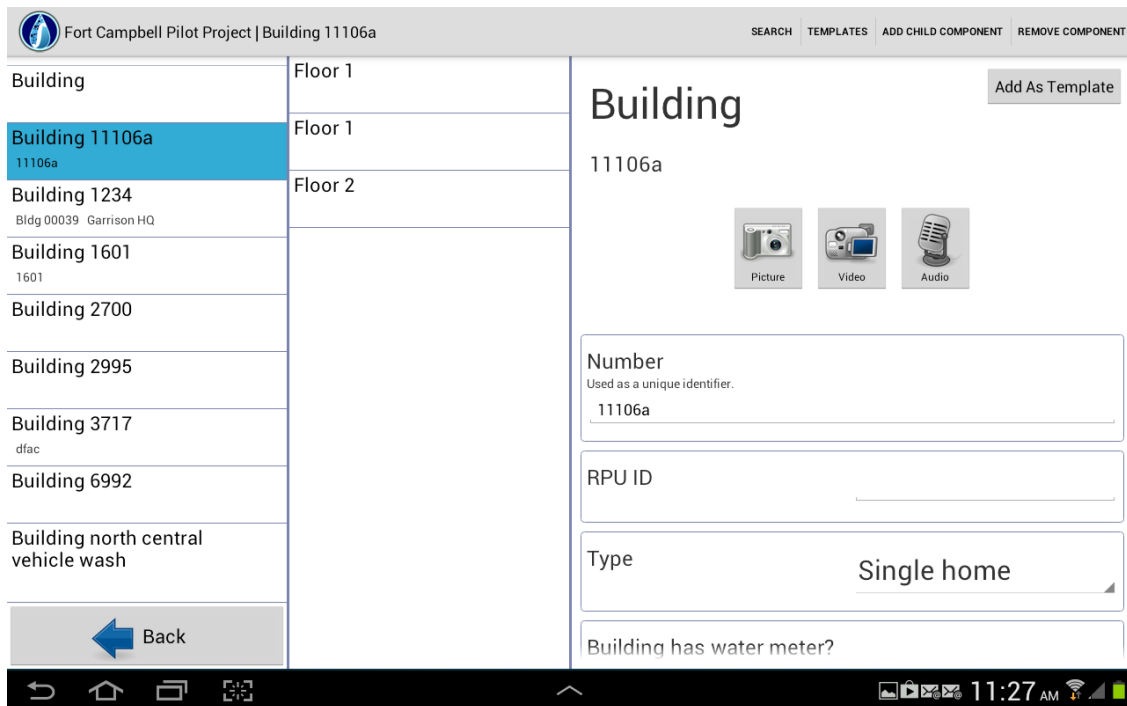


Figure 18. Adding a floor level.

3. Select the floor where you wish to add algorithm data. To add data, select the field in the third column (e.g., number of rooms with water equipment)

and type in data specific to this floor level (Figure 19). Similarly to the building level data fields, some fields require manual entry and others have menu items.

Fort Campbell Pilot Project | Building | Floor

SEARCH | TEMPLATES | ADD CHILD COMPONENT | REMOVE COMPONENT

**Building**  
Bldg 00039 Garrison HQ

**Floor 1233** New

**Floor** Add As Template

Picture Video Audio

**Number**  
Used as a unique identifier.  
1233

**Notes**

**Number of Rooms with Water Equipment** 1

Back

Figure 19. Adding data to a floor level.

### 7.3.10.3 Room level

1. A room level can be added to the floor level. This can be done by selecting the floor in which you wish to add a room and selecting the **Add Child Component** icon. Similarly to the floor level, one room can be added or up to 100 (Figure 20).

ADD CHILD COMPONENT

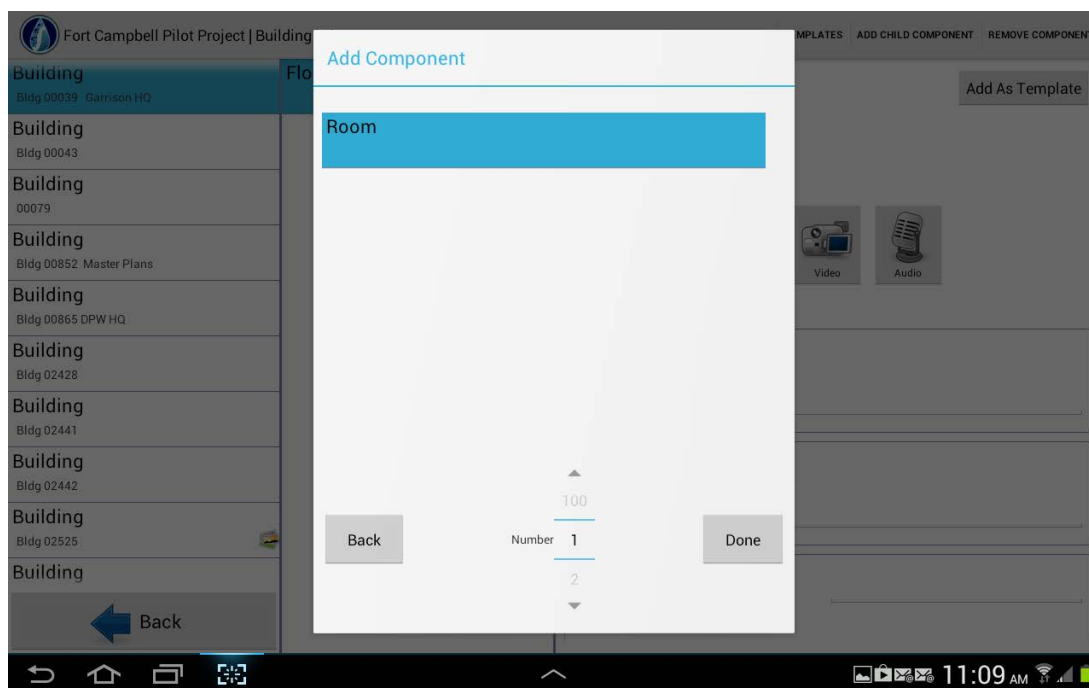


Figure 20. Adding a room level.

2. Select the room to add algorithm data. To add data, select a field in the third column and type in data specific to this room or select data from menu items (Figure 21).

*Note: A user may indicate that the room represents additional rooms on the floor. In this case, an audit of other represented rooms is not necessary.*

Figure 21. Adding room level data.

#### 7.3.10.4 Fixture level

1. A fixture level can be added to a room level (Figure 22). This can be done by selecting the room in which you wish to add a fixture or multiple fixtures and then selecting the **Add Child Component** icon.
2. Select the fixture that you would like to add and press “done.”

ADD CHILD COMPONENT

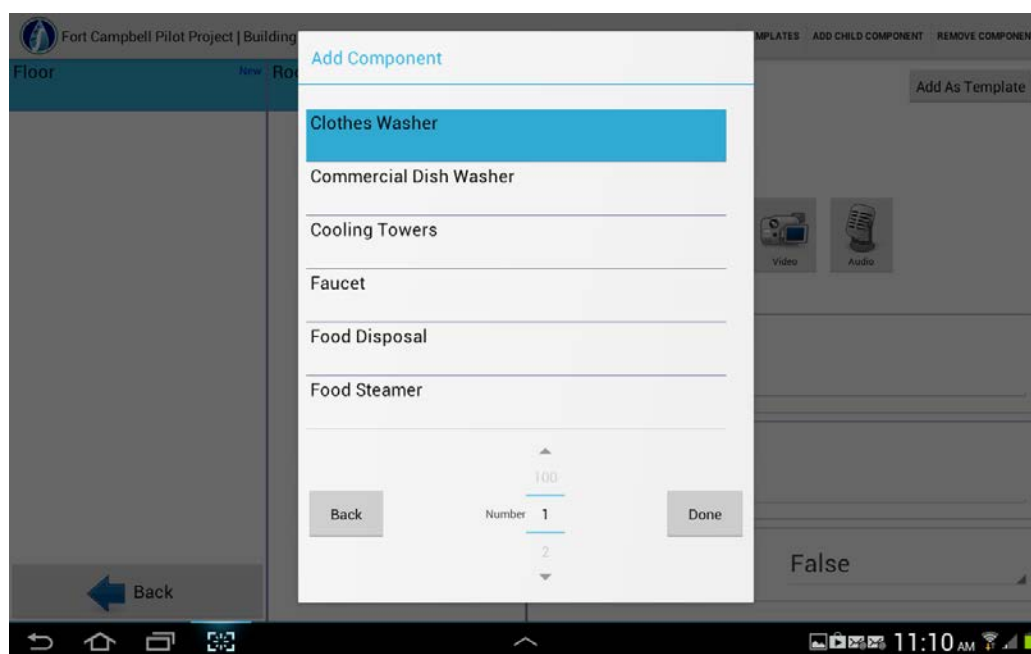


Figure 22. Adding fixture data.

- Rooms may have multiple types of fixtures. For example, a men's bathroom may include faucets, showerheads, toilets, and urinals (Figure 23).

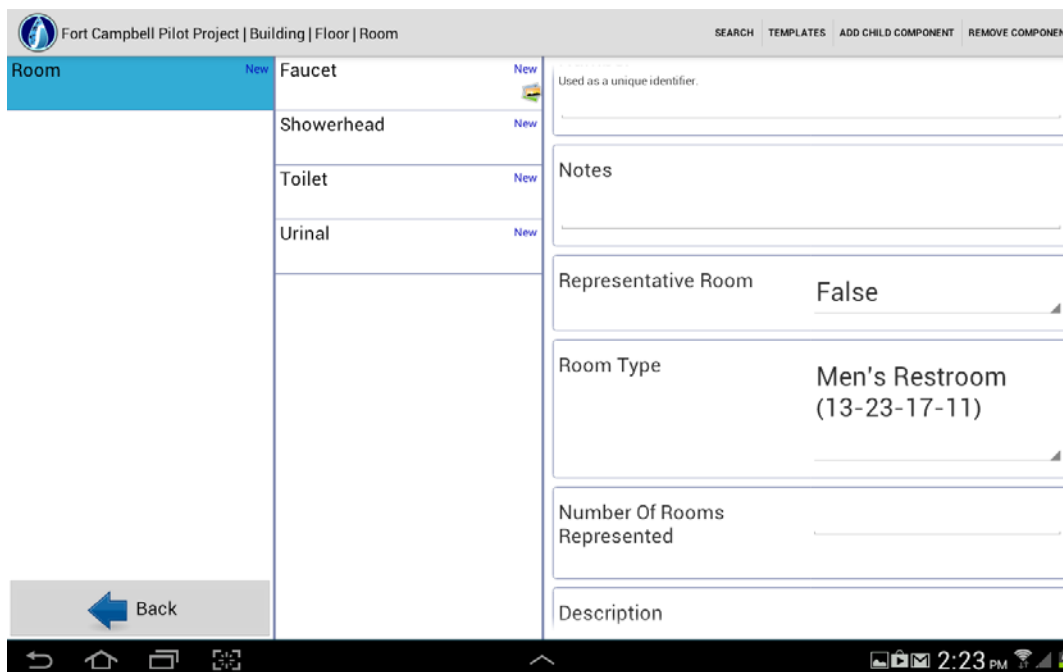


Figure 23. Fixture data fields.

- Each fixture type requires the user to enter algorithm data. To add data, select field in the third column and type in data specific to this fixture or select data from menu items (Figure 24).

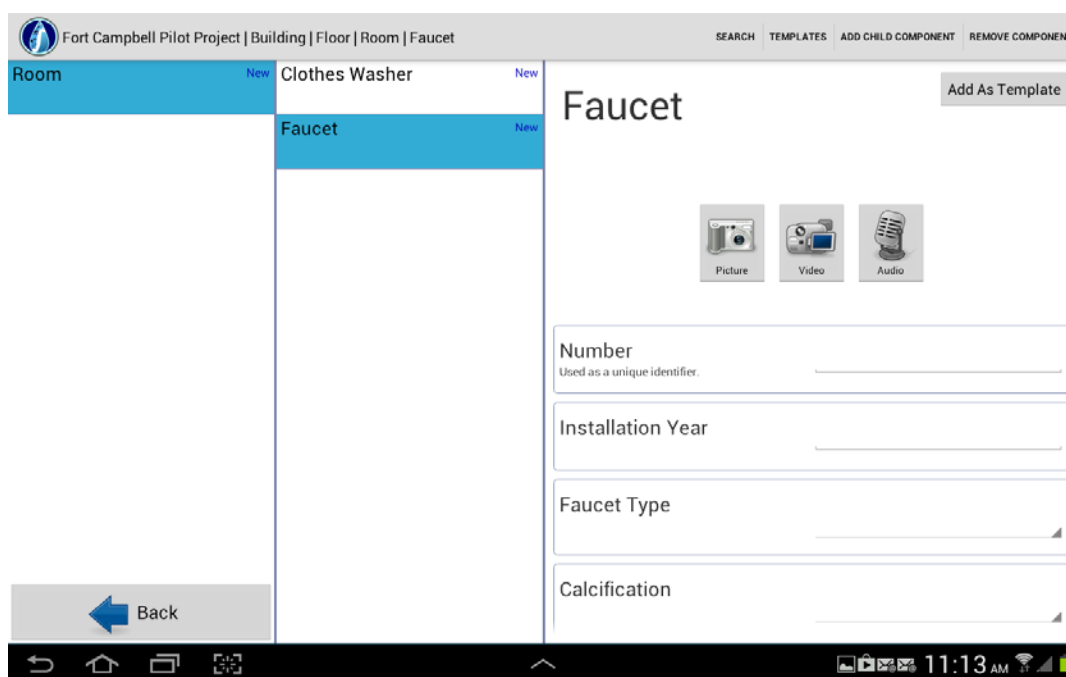
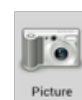


Figure 24. Adding data to fixture level.

### 7.3.11 Taking photos

1. The MICA:AM software allows the user to document buildings, rooms, and fixtures throughout the auditing process. For example if you wish to take a picture of a faucet, you must select the “faucet” tab.
2. To take a photo, point the mobile device at the desired object and then select the picture icon located in the third column.



You will notice a red button in the photo screen, press the button and then press the green check “done” button (Figure 25).



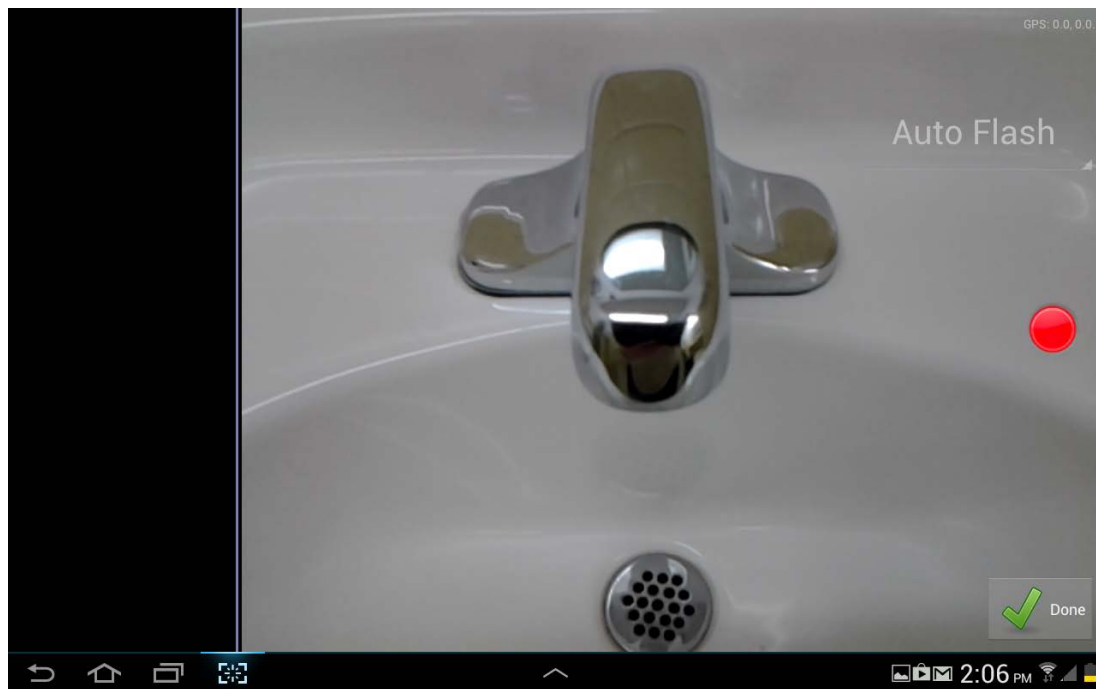


Figure 25. Taking a photo.

3. Once you press “done,” it will return to the fixture screen. You can either press the **red X** to delete the photo or leave it. This automatically saves the photo along with the fixture data. To add comments to the photo, select the “text” icon located at the bottom right of the photo thumbnail (Figure 26).



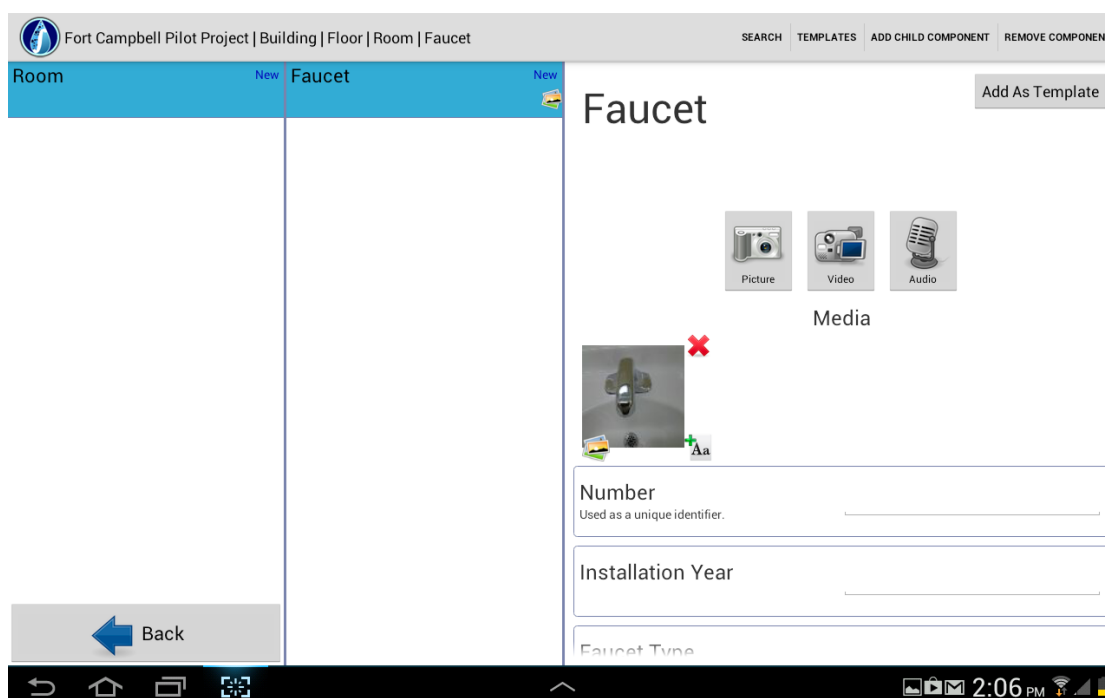


Figure 26. Adding comments.

4. A picture icon will appear next to the level tab located in the second column (i.e., faucet) to indicate that a photo has been taken.

### 7.3.12 Making templates

1. During the audit process, the user may notice the same type of fixtures, rooms, irrigation systems, etc. located throughout the installation. In this case, a user may wish to make a template to expedite the audit. To make a template, select the desired fixture, room or floor (Figure 27). For example, if you wish to make a template of a faucet, select the fixture and then press the **Add as Template** button located in the top-right corner of the screen.
2. You will be prompted to save the template. Save it with a name that is representative of the template, as you may have multiple templates.

Add As Template

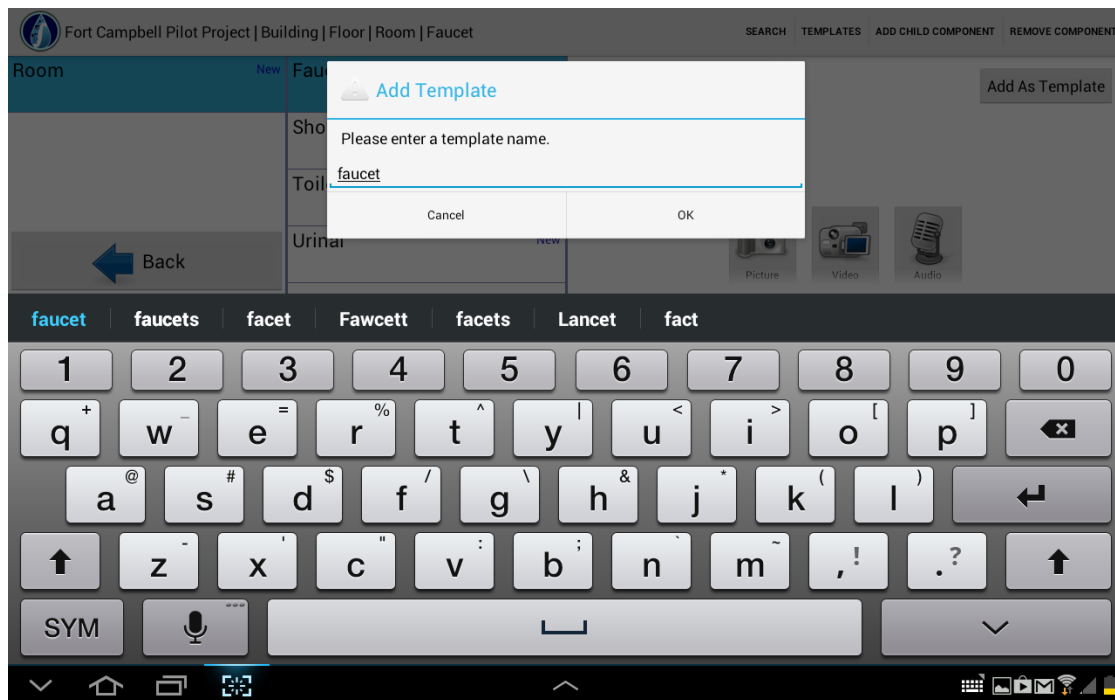


Figure 27. Adding templates.

3. To select a template that you have created, click the **Add Child Component** icon at the level where you have save a template. For instance, a toilet template that was created at the fixture level will be retrieved from that level (Figure 28).



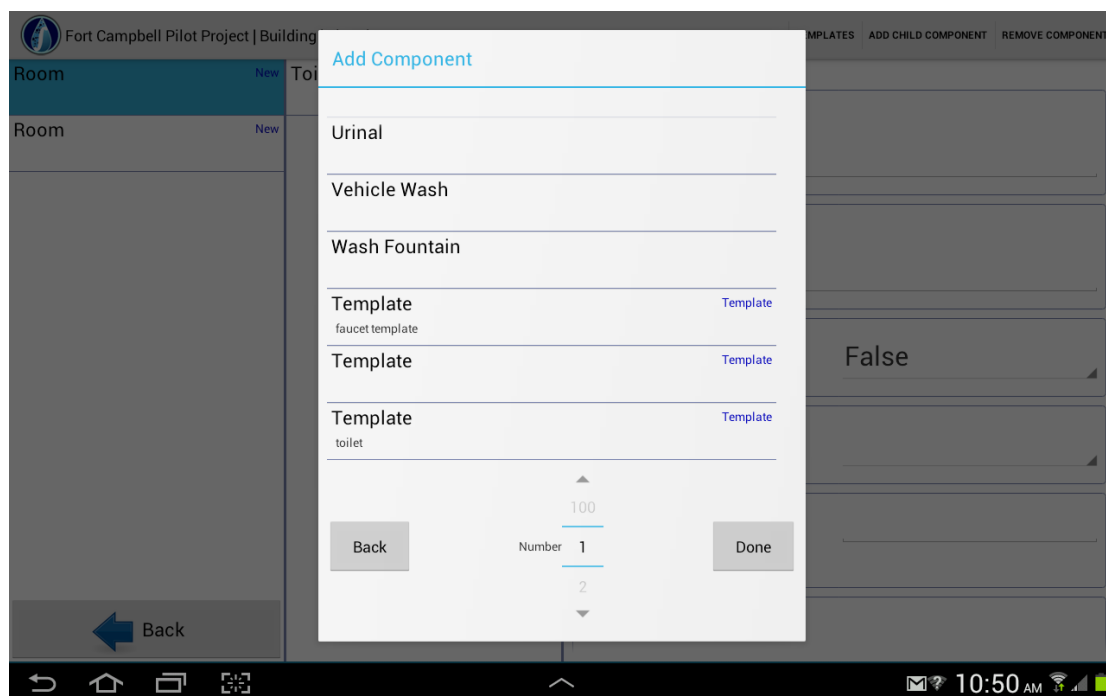


Figure 28. Selecting a template.

### 7.3.13 Editing templates

1. Although fixtures may be the same, specific data related to the audit will need to be entered into the fields. For example, auditing a faucet requires data specific to the fixture (i.e., type, flow rate, etc). To edit or add different data at the room or fixture level, select the template you wish to use and change the data within the fields. Figure 29 shows a template at the fixture level. To edit, select the fields you wish to edit, the changes made to the template will automatically be saved.

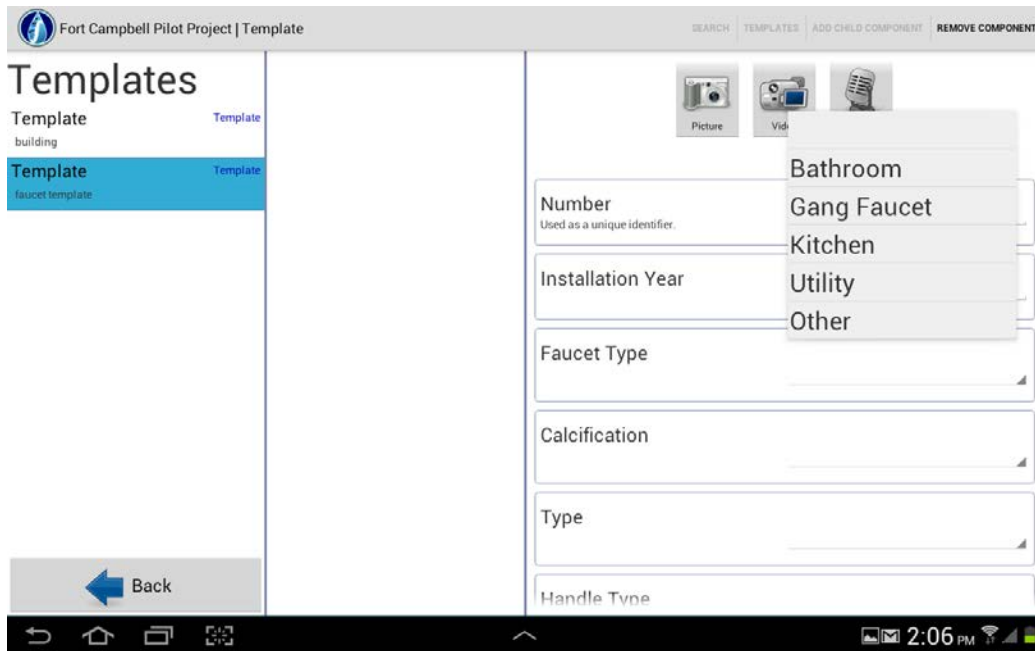


Figure 29. Editing a template at fixture level.

2. Templates may also be edited at any level. To edit a template, navigate to a screen in which the **Templates** button is visible at the top of the screen (Figure 30).

TEMPLATES

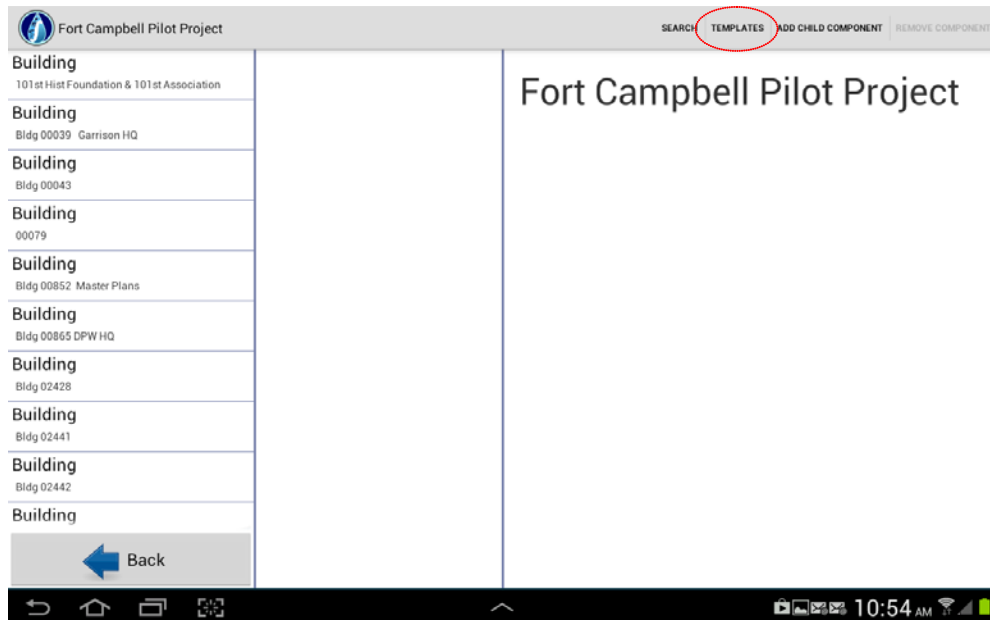


Figure 30. Editing a template at any level.

3. Select the template you wish to edit and enter the changes into the fields (Figure 31).

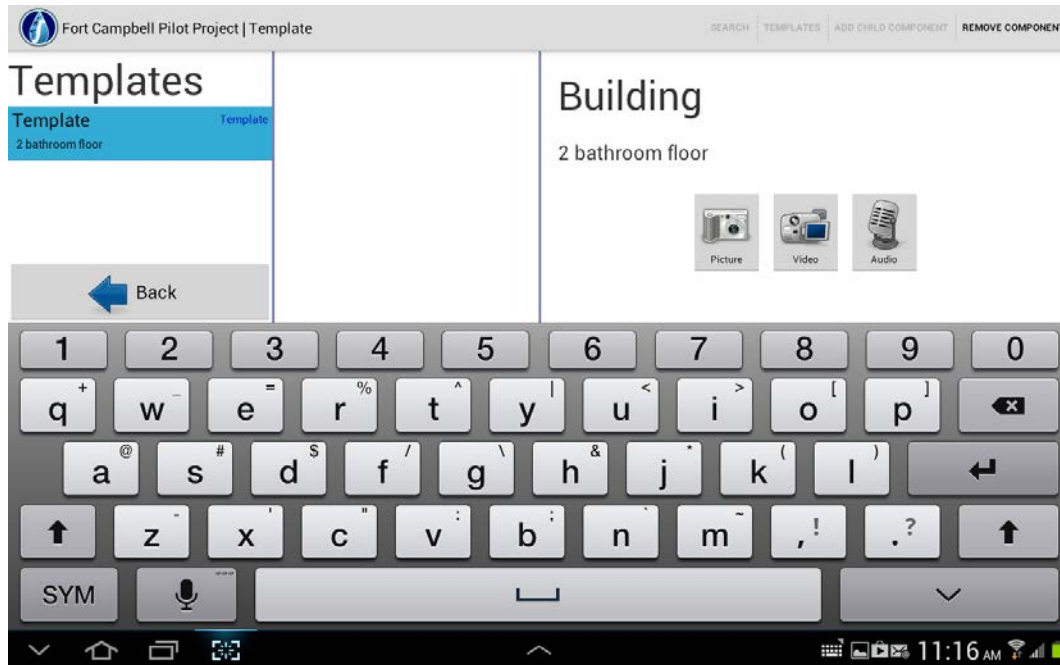


Figure 31. Selecting a template.

### 7.3.14 Rooms that represent other rooms

1. The auditing process will not include an audit of all rooms with fixture. The goal is to audit at least 10% of the building. In the case where of multiple rooms on the same floor have similar fixtures (i.e., bathrooms), you should audit one room and indicate that it represents additional rooms. In the example below, five men's restrooms have identical fixtures (Figure 32).

*Note: Before the audit of a room, scan the floor to see if there are multiple rooms with identical fixtures. This is when you may want to note that it represents other rooms.*

Fort Campbell Pilot Project | Building | Floor 123 | Room

SEARCH | TEMPLATES | ADD CHILD COMPONENT | REMOVE COMPONENT

Floor 123  
all rooms are the same

New Room 567  
all the same

Notes

Representative Room True

Room Type Men's Restroom (13-23-17-11)

Number Of Rooms Represented 5

Description  
all the same

Back

11:32 AM

Figure 32. Rooms that represent other rooms.

### 7.3.15 Removing child components

1. To remove a child component (i.e., floor, room, fixture) select the component you wish to remove and press the **Remove Component** button located at the top-right of the screen (Figure 33).



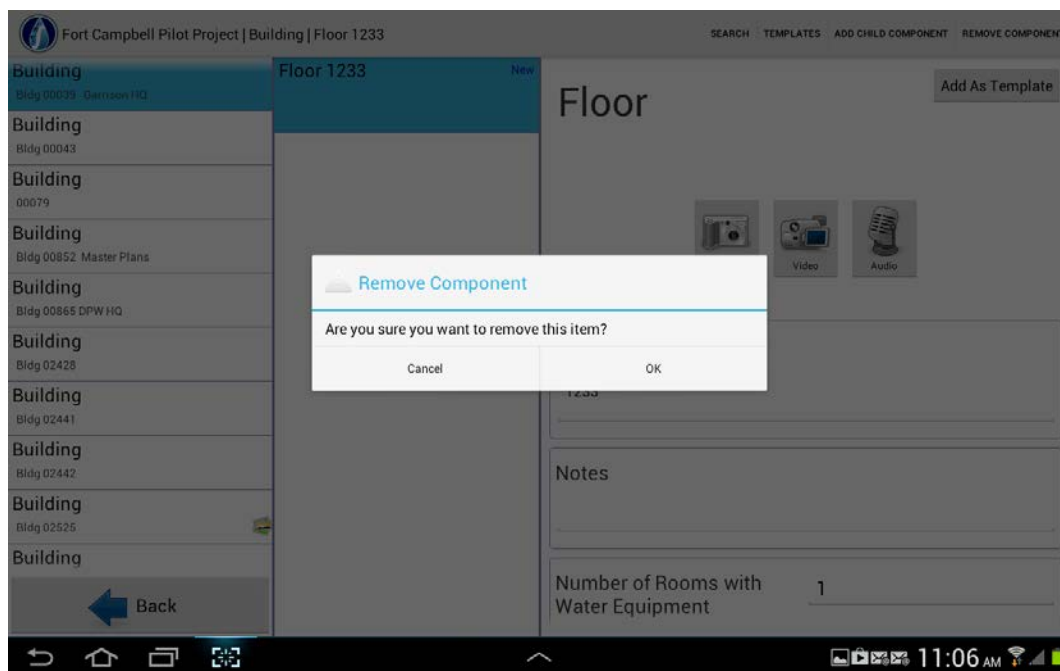


Figure 33. Removing a component.

2. Once you select the child component, it will ask if you want to remove the item. Select OK to remove or Cancel.

### 7.3.16 Irrigation

1. To add irrigation systems to the building level select the **Add Child Component** icon and add “irrigation.” To enter data, select the irrigation tab and begin filling in the fields (Figure 34).



Fort Campbell Pilot Project | Building

SEARCH TEMPLATES ADD CHILD COMPONENT REMOVE COMPONENT

Building Bldg 00039 Garrison HQ

Building Bldg 00043

Building 00079

Building Bldg 00852 Master Plans

Building Bldg 00865 DPW HQ

Building Bldg 02428

Building Bldg 02441

Building Bldg 02442

Building Bldg 02525

Back

Irrigation New

Building Bldg 00039 Garrison HQ

Add As Template

Picture Video Audio

Number  
Used as a unique identifier.

RPU ID

Type

Building has water meter?

11:07 AM

Figure 34. Adding irrigation.

2. Data for irrigation will likely include a mix of data collected onsite and through interviews (Figure 35). You will need to coordinate with the POC of operations or maintenance before or during the audit process to know the start/end of irrigation, and other information specific to the system.

Fort Campbell Pilot Project | Building 1234 | Irrigation

SEARCH | TEMPLAT | IENT

Building

Building 11106a

Building 1234  
Bldg 00039 Garrison HQ

Building 1601

Back

Irrigation New

Is Irrigation Metered?

Start of Irrigation Season

Last Month of Irrigation

Mar  
Apr  
May  
Jun  
Jul  
Aug  
Sep  
Oct  
Nov  
Dec

Next

1 2 3 4 5 6 7 8

+ - × ÷ = % £ €

@ # \$ / ^ & \* ( )

1/2 - ' " : ; ! ? , . 1/2

ABC T

11:23 AM

Figure 35. Types of data.

### 7.3.17 Alternative water options

1. To add alternative water options systems to the building level, select the **Add Child Component** icon and add alternative water options. To enter data, select the Alternative Water Options tab and begin filling in the fields (Figure 36).

ADD CHILD COMPONENT

Fort Campbell Pilot Project | Building | Alternative Water Options

SEARCH TEMPLATES ADD CHILD COMPONENT REMOVE COMPONENT

**Building**  
101st Hirst Foundation & 101st Association

**Alternative Water Options** New

Add As Template

**Alternative Water Options**

Picture Video Audio

Alternative Water Source **Gray Water**

Collection Location

Type of Water Collection

Back

11:00 AM

Figure 36. Adding alternative water.

## 7.4 Accessing the data after auditing

After uploading the data from the tablet, the data are immediately available on the NZI web portal. (Appendix B to this report contains screen shot examples.) Downloadable data will be in Excel® format. Currently every file will have a summary table showing rollup data of all items found within the building and building level demand estimates. In addition, there will be separate tabs for each equipment type with specific details relating to that equipment, its condition, and its location. The exact format that will be available is still under development and may change depending on feedback from operators.

## 7.5 Next steps

The objective for the FY14 project is to use previously collected field data for the four installations to test existing formulas used to calculate water use. For example, MICA:WET was used at Fort Leonard Wood to conduct a water audit in June 2013. Some of the buildings were also metered. To determine the accuracy of existing water use assumptions, CERL will compare the available meter data from Fort Leonard Wood to the estimates created by MICA:WET algorithms. The MICA:WET algorithms will then be adjusted. The adjusted algorithms will then be calibrated with the metered water use data.

By calibrating the MICA:WET algorithms, CERL will be able to more accurately estimate water demand for facilities that lack water meters. The majority of Army facilities have few installed, working water meters; the corrected MICA:WET algorithms provide an alternative that will quickly capture facility level water consumption throughout an installation. These data can then be used for planning future water efficiency and conservation projects. In addition, the use of MICA:WET on portable devices will enable installations to collect and analyze water data quickly, with fewer errors, and to create immediate building level estimates of water use.

At the time of publication the MICA:WET tool was available for collecting inventory data for water equipment. Feedback from energy and water managers is needed to further refine the data output so that it will be more useful to them. In addition, several minor changes will be made to interface aspects in response to suggestions by auditors, e.g., the order of questions, or options available for washer brands.

## 8 Conclusion

This work has developed the MICA:WET tool to help installation managers, planners, and modelers track water conservation projects and equipment at the building level, to meet the requirements of EISA 2007, and has performed field tests to test MICA:WET and preliminarily outline training needed to enable installation personnel to use MICA:WET at their locations. This easily revised database is designed for compatibility with existing management systems such as BUILDER and the Net Zero Installation Tools. MICA:WET provides operators with access to data in Excel® spreadsheet format, and planners and modelers with accurate installation-wide indoor and outdoor summaries of buildings and their standard water equipment.

MICA:WET tracks water-related equipment at the building level, and collects and stores that information in an easily usable database that installation operators can use to document existing and estimate future water demand. Since many military installations do not have individual facility water meters, MICA:WET has also been designed to use algorithms to estimate building level water use to determine tenant use until individual meters and/or sub-meters are installed. Once established, MICA:WET will provide a one-stop reference for water data that will serve as an easy source for updated equipment on subsequent iterations for planning models such as the DSS model or other appropriate planning tools.

## Acronyms and Abbreviations

| <u>Term</u> | <u>Definition</u>                                                        |
|-------------|--------------------------------------------------------------------------|
| AIT         | Advanced Individual Training                                             |
| ASA(IEE)    | Assistant Secretary of the Army (Installations, Energy, and Environment) |
| AWWA        | American Water Works Association                                         |
| AWWARF      | American Water Works Association Research Foundation                     |
| CAC         | Common Access Card                                                       |
| CAT         | Category                                                                 |
| CEERD       | US Army Corps of Engineers, Engineer Research and Development Center     |
| CERL        | Construction Engineering Research Laboratory                             |
| CTS         | Compliance Tracking System                                               |
| DFAC        | Dining Facility                                                          |
| DPW         | Directorate of Public Works                                              |
| DSS         | Decision Support System                                                  |
| DUSD, I&E   | Deputy Undersecretary of Defense, Installations, Environment             |
| EISA        | US Energy Independence and Security Act of 2007                          |
| EMS         | Engineered Management System                                             |
| ERDC        | Engineer Research and Development Center                                 |
| ESTCP       | Environmental Security Technology Certification Program                  |
| ET          | Evapotranspiration                                                       |
| FEDS        | Facility Energy Decision System                                          |
| FY          | Fiscal Year                                                              |
| HNC         | US Army Engineering and Support Center, Huntsville, AL                   |
| HQ          | Headquarters                                                             |
| IPR         | In Progress Review                                                       |
| IR          | infrared                                                                 |
| ITL         | Information Technology Laboratory                                        |
| LEED        | Leadership in Energy and Environmental Design                            |
| MDM         | Mobile Device Management                                                 |
| MRE         | Meals Ready To Eat                                                       |
| MWR         | Morale, Welfare, and Recreation                                          |
| NCO         | Non-Commissioned Officer                                                 |
| NZI         | Net Zero Installation                                                    |
| NZIT        | Net Zero Installations Tool                                              |
| NZW         | Net Zero Water                                                           |
| OCA         | Operational Condition Assessment                                         |
| OMB         | Office of Management and Budget                                          |
| PAO         | Public Affairs Office                                                    |
| PIN         | Personal Identification Number                                           |

---

| <b><u>Term</u></b> | <b><u>Definition</u></b>                |
|--------------------|-----------------------------------------|
| PNNL               | Pacific Northwest National Laboratory   |
| POC                | Point of Contact                        |
| PT                 | Physical Training                       |
| RPU                | Remote Processor Unit                   |
| TEMF               | Tactical Equipment Maintenance Facility |
| TR                 | Technical Report                        |
| TWDB               | Texas Water Development Board           |
| UPH                | Unaccompanied Personnel Housing         |
| US                 | United States                           |
| USAASC             | US Army Acquisition Support Center      |
| USACE              | US Army Corps of Engineers              |
| USGBC              | US Green Building Council               |
| VPN                | Virtual Private Network                 |
| WAP                | Wireless Access Point                   |
| WES                | Waterways Experiment Station            |
| WWW                | World Wide Web                          |

## References

- Albrecht, Terry. 2010. *Conducting a water audit and reviewing methodologies*. PowerPoint presentation. Water Reduction Partners.
- American Water Works Association (AWWA). 2009. *Water Audits and Loss Control-Manual 36*. Denver, CO: AWWA.
- American Water Works Association Research Foundation (AWWARF). 1999. *Residential End Uses of Water*. Denver, CO: AWWARF.
- . 2000. *Commercial and Institutional End Uses of Water*. Denver, CO: AWWARF.
- Boyd, B. K., S. A. Brown, J. E. Cabe, and E. L. Giever. 2012. *Fort Buchanan net zero water program water balance report*. Richland WA: Pacific Northwest National Laboratory (PNNL).
- Cabe, J. E., S. A. Brown, J. L. Williamson, and M. I. De La Rosa. 2012. *Fort Bliss net zero water balance*. Draft report. Richland WA: PNNL.
- Elam, E. C., F. W. Wheeler, P. R. Bassett, J. W. Dupre, and B. K. Boyd. 2012a. *Aberdeen Proving Grounds net zero water program water balance report*. Draft report. Richland WA: PNNL.
- Elam, E. C., F. W. Wheeler, P. E. Basset, J. W. Dupre, and K. L. McMordie-Stoughton. 2012b. *Camp Rilea net zero water balance report*. Draft report. Richland WA: PNNL.
- Elam, E. C., F. W. Wheeler, P. E. Basset, J. W. Dupre, and K. L. McMordie-Stoughton. 2012c. *Fort Riley net zero water balance report*. Draft report. Richland WA: PNNL.
- Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL). 2007. BUILDER EMS Version 3 User Manual. Champaign, IL: ERDC-CERL, [http://sms.cecer.army.mil/Shared%20Documents/Downloads/BUILDER/builder3\\_full.pdf](http://sms.cecer.army.mil/Shared%20Documents/Downloads/BUILDER/builder3_full.pdf)
- Fort Campbell. 2012. Fort Campbell website, <http://www.campbell.army.mil/UNITS/Pages/Welcome.aspx>
- Fort Hood Public Affairs Office (PAO). 2009. *Fort Hood quick facts*. Fact Sheet. Fort Hood TX: Fort Hood PAO, <http://www.hood.army.mil/facts/FS%200702%20-%20Fort%20Hood%20Quick%20Facts.pdf>
- Fundamental Audits, Inc. 2013. foAudits: The first and fastest toolset for mobile audits. *foAudits: Solar Audits*. Web site. Accessed 23 July 2013, <http://www.foaudits.com/>
- Johnson, Kelsey. Primary Investigator for EISA 2007 Evaluation Training project. Interviewed by Laura Curvey, 3 June 2013.

- Macumber, Daniel. 2013. *Simu-watt: Energy auditing tool with geometry capture*. IPR presentation. Golden, CO: National Renewable Energy Laboratory (NREL).
- Maddaus, Michelle. Maddaus, Inc. Interviewed by Laura Curvey, November 2013.
- Mathis, Mark, George Kunkel, and Andrew Chastain Howley. 2008. *Water loss audit manual for Texas utilities*. Austin, TX: Texas Water Development Board (TWDB), [http://www.twdb.texas.gov/publications/brochures/conservation/doc/WaterLossManual\\_2008.pdf](http://www.twdb.texas.gov/publications/brochures/conservation/doc/WaterLossManual_2008.pdf)
- Mayer, Peter W., and William B. DeOreo. 2013. *Update and expand residential end uses of Water Project #4309, Reporting Period: May 2012–Feb 2013*. Denver, CO: Water Research Foundation, [http://www.waterrf.org/ProjectUpdates/Update4309\\_Feb2013.pdf](http://www.waterrf.org/ProjectUpdates/Update4309_Feb2013.pdf)
- McMordie Stoughton, K. L. Phone interviewed by Laura Curvey, January 2013.
- McMordie Stoughton, K. L., et al. 2012. *Fort Carson net zero water balance*. Richland WA: PNNL.
- McMordie Stoughton, K. L., et al. 2012. *Joint Base Lewis McChord net zero water balance*. Draft report. Richland WA: PNNL.
- MyBaseGuide.com. 2012. MSCoE. *MyBaseGuide*. Web site. Accessed 28 August 2013, <http://mybaseguide.com/article/army/ft-leonard-wood/1714/MSCoE>
- Pacific Institute. 2009. Improving efficiency is critical for sustaining water resources, but energy demands on water are growing. *YubaNet.com*. Web site. Accessed 28 August 2013, <http://yubanet.com/usa/Per-Capita-Water-Use-in-the-U-S-Drops.php>
- Underwood, David M., Alexander M. Zhivov, Dieter Neth, Stephan Richter, Ross Montgomery, Alfred Woody, Harold Neuner, Susanne Ochse, and Scott Wood. 2010. *Energy assessment at Army installations In Korea: Camp Carroll, Camp Henry, Camp Humphreys, and Camp Walker*. ERDC/CERL TR-10-23. Champaign, IL: Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL).
- US Army Acquisition Support Center (USAASC). 2011. *New analytic tool supports master planning for net zero installations*. Web page. Accessed 27 August 2013, <http://asc.army.mil/web/new-analytic-tool-supports-master-planning-for-net-zero-installations/>
- US Green Building Council (USGBC). 2009 (updated 2012). *Water use reduction additional guidance*. LEED Document 6493. Version 7.
- Vickers, Amy. 2001. *Handbook of water use and conservation*. Amherst, MA: WaterPlow Press.

## Appendix A: Supplemental Sources

### A.1 Water audit “cheat sheet”

#### A.1.1 Room/floor/building

BE SURE TO RECORD THE RESPECTIVE BUILDING/FLOOR/ROOM FOR EVERY AUDIT.

##### A.1.1.1 *Faucets*

1. Turn on faucets for normal use. You do not need to try to open them full blast.
2. Use infrared (IR) gun to measure cold water temperature first.
3. Move (if levered) to hot and, while waiting for the hot water, take a ‘flow bag’ and measure the faucets flow rate for 5 seconds. Do it twice to get an average.
4. Record the rated flow. It should be located on the aerator at the mouth of the faucet engraved on the metal. It may be covered with built up calcium so may have to clean and rub off the residue. You may also need a magnifying glass to overcome difficulty with the small text.
5. After 20–30 seconds of hot water flow, use the IR gun to get the hot water temperature. Measure the temperature until it stops rising. Record only the highest temperature shown on IR gun.
6. Record the faucet’s brand (make) and type.

##### A.1.1.2 *Toilets and urinals (if flushometer):*

1. Look for rated flow on the crown, front, or back of flushometer or look at the bowl behind the hinge of the seat if cannot find it on the flushometer. You may need a mirror to see the back of flushometer.
2. Record if the toilet is operated manually or by a sensor.
3. Pull or activate the flush. Begin timing once water starts to flow. Record the flush duration in seconds in the tablet.
4. Record the brand (make) of the flushometer (not of the toilet bowl).

##### A.1.1.3 *Toilets (tankless or tank).*

1. Record the rated flow only.

#### A.1.1.4 Dining facilities

1. Interview the Dining Manager. In addition to the routine data input in the tablet, request and note whether the method of preparing food uses a notable amount of water, e.g., if water is constantly running, etc.

#### A.1.1.5 Large Appliances (commercial/residential)

1. Take a photo of model, model No., and serial No.
2. MAKE TEMPLATES. (See the manual for details.)

## A.2 Differences between piston and diaphragm toilet valves

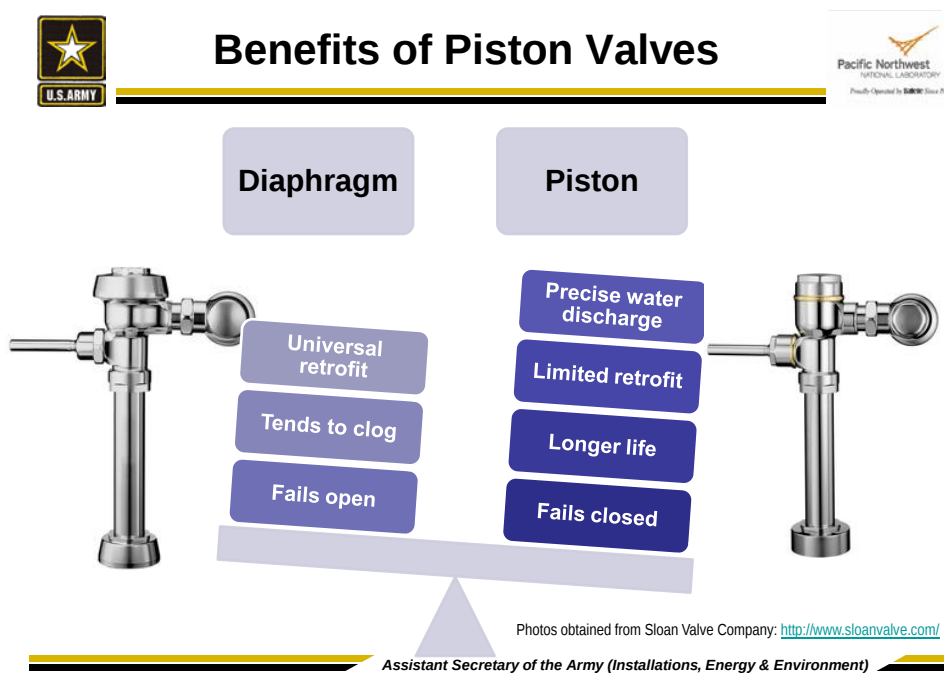


Figure A1. Differences between piston and diaphragm valves.

### A.2.1 Valve information

*Background information for the information in this section was provided by Kate McMordie Stoughton, PNNL (2013).*

Almost all flush valve toilets in commercial settings have diaphragm valves. The can be identified by their characteristically larger head on the valve (Figure A1). Piston valves have distinct advantages over diaphragm valves. Piston valves deliver a precise amount of water, are tolerant of lower pressure, and tend to require less maintenance because internal com-

ponents have a longer life. When they do fail, piston valves fail in the closed position. By contrast, diaphragm valves tend to corrode, and fail in the open position, which leaves water continuously leaking.

### **A.2.2 Detailed valve information**

Piston valves are precise, and deliver the desired flow, even as they age. Piston valves perform at  $\pm 5\%$  accuracy of the designed flow, whereas diaphragm valves are substantially less accurate near  $\pm 20\%$  of the designed flow. Diaphragm inaccuracy is more prevalent at high and low pressure extremes.

Piston valves are more tolerant of low pressures experienced at certain times of the day and certain building applications. Piston valves are rated at a minimum pressure of 15 psi, as opposed to diaphragm type valves that require at least 35 psi to operate accurately.

Piston valves are virtually maintenance free for 5 to 7 years. Their long life and robust internal components (that seldom need to be replaced) keep their maintenance costs low. Diaphragm valves, on the other hand, require periodic maintenance. Diaphragm valves currently in use depend on a tiny pinhole to meter the flow of water. This pinhole will often corrode or clog, causing flush volume to increase and decrease. Diaphragms must be changed regularly, at an average cost of \$5.00 per year per valve.

Piston valves are available with an inlet screen that protects the timing orifice. The inlet screen is positioned so that it is backwashed with every flush. This dramatically lessens the probability that the valve-timing orifice will become clogged with debris.

The valve housing of a diaphragm type valve can accommodate any flow rate diaphragm. Thus, a common mistake is to replace an efficient valve with a higher flow diaphragm rather than taking the time to search for or purchase the proper component. This inappropriate substitution instantly converts a high efficiency toilet into a water-wasting 3.5 gpf toilet. This presents a major concern in any guaranteed performance based contract, since the improper maintenance diminishes calculated savings.

## A.3 Equipment reference websites

### A.3.1 Food steamers

Boiler/convection steamers typically require a water line and consume a large quantity of water.

Boilerless electric steamers, on the other hand, require very little water and no water connection:

[http://www.kirbysupply.com/Equipment/Cooking\\_Equipment/Accutemp/Connectionless\\_Steamers/accutemp\\_Connectionless\\_Steamers.htm](http://www.kirbysupply.com/Equipment/Cooking_Equipment/Accutemp/Connectionless_Steamers/accutemp_Connectionless_Steamers.htm)

Notice that the boiler has a base that houses the water lines and steamer; the boilerless unit does not. The boilerless unit just has a pan that is manually filled on an as-needed basis because it uses very little water.

### A.3.2 Ice machines

This link provides basic information to learn about the energy/water efficiency of ice machines:

<http://www.fishnick.com/publications/icemachines/>

After an audit, this site may a good reference to look up ice machine model numbers to get their consumption rating:

<http://www.ahridirectory.org/ahridirectory/pages/acim/defaultSearch.aspx>

#### A.3.2.1 *Visual differences between air-cooled and water cooled ice machines*

Air-cooled machine typically have ports (one port for water) and the cord located in the rear: <http://www.icemachinesplus.com/ice-o-matic-iceu070a.html>

#### A.3.2.2 *Water cooled*

Water cooled machines, which use more water than their air-cooled counterparts, have an additional port for excess water to run out:

<http://www.icemachinesplus.com/scotsman-afe424w-1.html>

### A.3.3 Water conservations for commercial food service

This link provides some insight on general practices and equipment recommendations within a kitchen and it may provide you some guidance as to what to look for within a kitchen as you audit it and take notes:

[http://www.fishnick.com/savewater/bestpractices/Water\\_Conservation\\_in\\_CFS.pdf](http://www.fishnick.com/savewater/bestpractices/Water_Conservation_in_CFS.pdf)

#### **A.3.4 Resources for steam sterilizer medical equipment**

Alliance for Water Efficiency (AWE). 2010. *Steam Sterilizers & Autoclaves Introduction*. Web site. Accessed 25 October 2013, <http://www.allianceforwaterefficiency.org/steam-sterilizers-and-autoclaves-introduction.aspx>

Koeller, John. 2004. *Potential Best Management Practices*. Yorba Linda, CA: Koeller and Company, [http://doczine.com/bigdata/2/1367127582\\_7bdb20d547/49019.txt](http://doczine.com/bigdata/2/1367127582_7bdb20d547/49019.txt)

Miller, Phillip Ray. 2005. *The Reduction in Water Consumption of Sterilizer Equipment Resulting From the Installation of Water-Mizer™ Systems*. St. Louis, MO: TDK Consulting Services.

van Gelder, Roger E., and Eaden John. 2003. *Field Evaluation of Three Models of Water Conservation Kits for Sterilizer Trap Cooling at University of Washington*. Seattle, WA: University of Washington.

## Appendix B: NZI Tool Screen Shots

Study List Study Information Building Optimization Installation or Subsection Decision Analysis Generate Planning Forms Developmental User

Details Facilities Utilities Manage Users

Study Information Details

Instructions

Baseline Alt 1 +

Edit All Edit

**Study Name: Portsmouth Naval Shipyard IE 0.14.2 (312)**  
 Param Version: 0.14.2  
 NZI Opt Version: 0.3.0  
 Created By: Timothy W Garton  
 Modified By: Developmental User  
 Last Edited: 11/20/2012 1:59 PM  
 Description: Testing all facility groups with existing, planned, and demolished combinations for both default and custom models.  
☐ Public Access

**Location and Meteorological Data**  
 Location: Portsmouth Naval Shipyard  
 Weather File: USA\_NH\_Peace.Intl.Tradeport.726055\_TMY3.epw  
 Climate Zone: ASHRAE 6A  
 Soil Type: ET

**This Study Includes:**  
☒ Energy  
☐ Water  
☒ Waste  
☐ Green House Gases

Completed  
 Study Information Building Optimization Installation or Subsection

Menu

- Contact Us
- Change Password
- Update Profile
- Request Role
- Manage Users
- Installation Administration

Figure B1. Draft screen for NZI Tool, study information, details (includes soil type and evapotranspiration [ET]).

Net Zero Installations Study: Portsmouth Naval Shipyard IE 0.14.2 2012.11.29 (Alpha 24)

Study List Study Information Building Optimization Installation or Subsection Decision Analysis Generate Planning Forms Developmental User

Details Facilities Utilities Manage Users

Study Weather and Climate

Weather File:  
 USA\_NH\_Peace.Intl.Tradeport.726055\_TMY3.epw

Climate Zone:  
 ASHRAE 6A

Soil Type:  
 ET

Back Continue

Menu

- Contact Us
- Change Password
- Update Profile
- Request Role
- Manage Users
- Installation Administration

Figure B2. Draft screen for NZI Tool, study information, details (soil & ET pull-down menus).

**Net Zero Installations** Study: Portsmouth Naval Shipyard IE 0.14.2 2012.11.21 (Alpha 24)

Study List Study Information Building Optimization Installation or Subsection Decision Analysis Generate Planning Forms Developmental User

Details Facilities **Utilities** Manage Users

**Study Utilities**

Instructions  
You must select at least one electric utility and one gas utility.  
Use the page controls to view multiple pages of utilities, or search to find a particular utility.

Energy Water Waste

Drag a column header and drop it here to group by that column

| Supplier | Type | Name | Enabled |
|----------|------|------|---------|
|----------|------|------|---------|

Add Utility

Utility Networks

Back Continue

- Contact Us
- Change Password
- Update Profile
- Request Role
- Manage Users
- Installation Administration

Figure B3. Draft screen showing study utilities with water and waste included.

**Net Zero Installations** Study: Portsmouth Naval Shipyard IE 0.14.2 2012.11.29 (Alpha 24)

Study List Study Information Building Optimization Installation or Subsection Decision Analysis Generate Planning Forms Developmental User

Details Facilities **Utilities** Manage Users

**Water Utility Source and Supply**

Water Source:  
Purchased

Water Supply:  
Reused

Back Continue

- Contact Us
- Change Password
- Update Profile
- Request Role
- Manage Users
- Installation Administration

Figure B4. Draft screen for NZI Tool, study information, utilities (including water).

## Appendix C: Fort Leonard Wood Water Audit

Table C1 lists the Fort Leonard Wood schedule for water audit (done 25-27 June 2013). Note that the **BOLD** numbered buildings were considered priority and the *italicized* buildings were considered secondary or opportunity buildings.

Table C1. Fort Leonard Wood schedule for water audit (6/25/13–6/27/13).

| Team 1 Priority List   |                                        |                                                                                     |                                                 |
|------------------------|----------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------|
| <i>Tuesday, 25-Jun</i> |                                        | <i>Wednesday, 26-Jun</i>                                                            | <i>Thursday, 27-Jun</i>                         |
| 9:00-11:00             | <b>6147</b> Trainee Barracks (metered) | 6105 Trainee BKS (metered)                                                          | 3200 MSCOE                                      |
| 10:30-12:00            | 6100 Battalion Headquarters            | <b>6104</b> Trainee BKS (metered)                                                   |                                                 |
| Lunch Break            |                                        |                                                                                     |                                                 |
| 2:30-3:30              | <b>6102</b> Trainee BKS (metered)      | <b>6111</b> DFAC                                                                    |                                                 |
| 2:30-3:30              | <i>6105 BCOF</i>                       | 604 Pool (Outdoor)                                                                  | 3200 MSCOE                                      |
| 3:30-4:00              |                                        | 1300 Indoor Pool                                                                    |                                                 |
| Team 2 Priority List   |                                        |                                                                                     |                                                 |
| <i>Tuesday, 25-Jun</i> |                                        | <i>Wednesday, 26-Jun</i>                                                            | <i>Thursday, 27-Jun</i>                         |
| 9:00-11:00             | <b>635</b> Training BKS                | 630 DFAC                                                                            | 3223 DFAC                                       |
| 10:30-12:00            | 636 Brigade HQ Bldg                    | 740 Battalion HQ Bldg                                                               | 616 CDC School Age                              |
| Lunch Break            |                                        |                                                                                     |                                                 |
| 1:30-3:30              | <b>817</b> Trainee Barracks            | <b>937</b> Trainee Barracks                                                         | <b>901</b> New Barracks                         |
| 2:30-3:30              | <i>822 Org Classroom</i>               | <i>894 Gen Inst Bldg</i>                                                            | <i>881 Vehicle Maintenance Shop</i>             |
| 3:30-4:00              | <b>836</b> DFAC                        | <i>804 Auditorium GP</i>                                                            | 490 Duel Food Court (metered)                   |
| 3:30-5:30              | <i>640 Phys Fit Center</i>             | <i>805 Recreation Center</i>                                                        | <i>885 Health Clinic (metered)</i>              |
| Team 3 Priority List   |                                        |                                                                                     |                                                 |
| <i>Tuesday, 25-Jun</i> |                                        | <i>Wednesday, 26-Jun</i>                                                            | <i>Thursday, 27-Jun</i>                         |
| 9:00-11:00             |                                        | 1731 Trans Unaccompanied Personnel Housing (UPH) Advanced Individual Training (AIT) | 4109 Consol Open Din (metered) 1789 AIT Barrack |
| 10:30-12:00            |                                        | 1732 Trans UPH AIT                                                                  | 5268 Car Wash 470 Admin Gen Purpose             |
| Lunch Break            |                                        |                                                                                     |                                                 |
| 1:30-3:30              |                                        | 1784 DFAC                                                                           | 11480 Tech Eq Maintenance Facility 1607 Museum  |
| 2:30-3:30              |                                        | 1910 Enlisted UPH                                                                   | 2200 Admin-DPW                                  |
| 3:30-5:00              |                                        |                                                                                     | 11470 Comp Op Facility                          |

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                             |                              |                                       | Form Approved<br>OMB No. 0704-0188                            |                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|------------------------------|---------------------------------------|---------------------------------------------------------------|-------------------------------------------|
| Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.                                                                                                                                                                                                                                                                                                                                                                                      |                             |                              |                                       |                                                               |                                           |
| 1. REPORT DATE (DD-MM-YYYY)<br>08-10-2013                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                             | 2. REPORT TYPE<br>Final      |                                       | 3. DATES COVERED (From - To)                                  |                                           |
| 4. TITLE AND SUBTITLE<br>Mobile Information Collection Application:<br>Water Equipment Tracker (MICA:WET) Tool                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |                              |                                       | 5a. CONTRACT NUMBER                                           |                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                             |                              |                                       | 5b. GRANT NUMBER                                              |                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                             |                              |                                       | 5c. PROGRAM ELEMENT                                           |                                           |
| 6. AUTHOR(S)<br>Laura E. Curvey, Rachel Phillips, Noel L. Potts, James Stinson, and Eric Roth                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                             |                              |                                       | 5d. PROJECT NUMBER                                            |                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                             |                              |                                       | 5e. TASK NUMBER                                               |                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                             |                              |                                       | 5f. WORK UNIT NUMBER                                          |                                           |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>US Army Engineer Research and Development Center (ERDC)<br>Construction Engineering Research Laboratory (CERL)<br>PO Box 9005,<br>Champaign, IL 61826-9005                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                             |                              |                                       | 8. PERFORMING ORGANIZATION REPORT NUMBER<br><br>ERDC TR-13-14 |                                           |
| 9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)<br>Office of the Assistant Secretary of the Army for Energy and Sustainability (ASA[IE&E])<br>110 Army Pentagon, Room 3E464<br>Washington, DC 20310-0110                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                             |                              |                                       | 10. SPONSOR/MONITOR'S ACRONYM(S)<br>ASA(IE&E)                 |                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                             |                              |                                       | 11. SPONSOR/MONITOR'S REPORT NUMBER(S)                        |                                           |
| 12. DISTRIBUTION / AVAILABILITY STATEMENT<br>Approved for public release; distribution is unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                             |                              |                                       |                                                               |                                           |
| 13. SUPPLEMENTARY NOTES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                             |                              |                                       |                                                               |                                           |
| 14. ABSTRACT<br>The Mobile Information Collection Application: Water Equipment Tracker (MICA:WET) tool is an Android application ('app') that provides a comprehensive means of tracking water equipment and conservation projects at the building level across an installation. The application's underlying database was built for compatibility with the BUILDER facility life cycle management and repair system officially adopted throughout the US Department of Defense (DoD). MICA-WET enables installation personnel to collect water-related facility data on an Android-based tablet during a facility assessment. The collected data are encrypted and uploaded via public Wi-Fi, to external servers, from which authorized users have immediate access. This report describes the MICA:WET app, and its use during field tests at five installations, Fort Hood, TX, Fort Campbell, KY, Fort Leonard Wood, MO, and two Engineer Research and Development Center (ERDC) laboratories. MICA:WET data collected from two of these installations are currently being used to propose water conservation projects. MICA:WET is also being developed to create estimates for installations that lack individual facility water meters, based on building water consumption from demographic and occupancy frequency estimates. |                             |                              |                                       |                                                               |                                           |
| 15. SUBJECT TERMS<br>MICA:WET, data management, water conservation, water consumption, android application                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                             |                              |                                       |                                                               |                                           |
| 16. SECURITY CLASSIFICATION OF:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                             |                              | 17. LIMITATION OF ABSTRACT<br><br>SAR | 18. NUMBER OF PAGES<br><br>92                                 | 19a. NAME OF RESPONSIBLE PERSON           |
| a. REPORT<br>Unclassified                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | b. ABSTRACT<br>Unclassified | c. THIS PAGE<br>Unclassified |                                       |                                                               | 19b. TELEPHONE NUMBER (include area code) |